The Art of Digital Fine Art Printing

Using today's inkjet Printers for Quality Prints

Uwe Steinmueller
Jürgen Gulbins

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Preface

Camera: Nikon D2X

Digital inkjet printers have been around for several years. Early consumer models provided neither the means for printing photographs with quality similar to common silver halogenid prints (normal photos on photo paper from film or slide) showed nor did inkjet prints offer the lightfastness of silver halogenid prints. For most users, the printers which delivered the desired image quality (e. g. IRIS prints) were rarely affordable. This has changed dramatically in the last few years, with 2005 giving a further push to the inkjet market. With the rise of digital photography, the demand and market for a new breed of inkjet printers arose and is now accommodated by manufacturers like Epson, HP, Canon, Lexmark, Dell and others.

One of the first A3+/Super B printers suitable for both fine art printing and the budget of a broad range of buyers was the Epson P2000, and even more the P2200 (P2100 in Europe). The breakthrough of this printer was based on its quality, reasonable price and its Ultrachrome ink set. A lot of images give the proper impression only when presented at an adequate size – 4 × 6 inches for most good images is not the optimum choice; they just don't impress. For many good shots, even Letter, Legal or A4 is not large enough. This is why A3+/Super B (about 13 × 19 inches) printers, at an affordable price, are important. There was an explosion of new printers of that size introduced in 2005 and it continues in 2006.

For some printing, it may be advisable to go even larger in size. Printer makers, like HP, Canon and Epson, also cover formats up to about 44" wide. There are many more large format printers out there (e.g. from Encad, Océ, Mutoh, Roland), yet most of them are really not designed for fine art printing. For this reason, we mainly deal with moderately sized prints and printers – typically from letter/A4 to C/A2. Most of the aspects we cover, however, will also apply to both smaller and larger printers and prints.

Put your feelings into a print

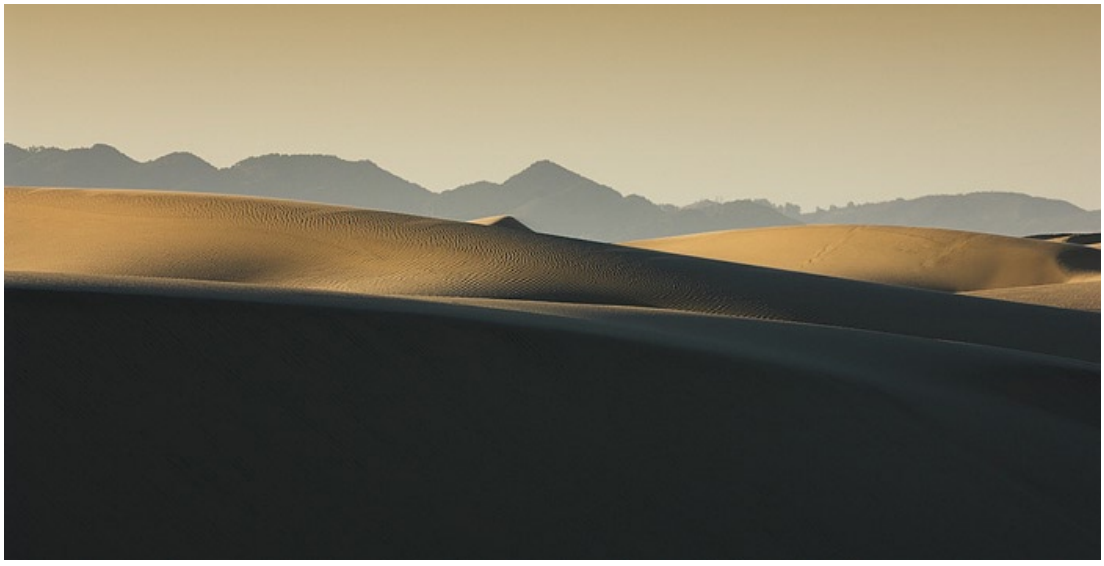
Though fine art printing may seem to be a particularly technical process, it may also be very emotional and sensual. As the term expresses, it is the printing of art and in an art-like manner. It allows you to lay down on paper an image created with your camera, you enhanced with your image application so that is closely represents the picture you had in mind when shooting the original. The print allows you to break away from the often restricting computer and display and recreate your vision to other people, possibly a broad audience – or give it away or even sell it. Today's fine art printing, using a good inkjet printer, allows you to produce a quality equalling or sometimes even surpassing that of silver-halonid prints, and is clearly able to surpass that of offset or rotogravure printing. Done properly, you can achieve a richer color gamut and finer tonal gradations than with traditional book and magazine printing techniques.

As with other kinds of art, without the proper knowledge and experience, the resulting print may not be totally predictable from the image on your computer monitor, and you may have to try sev-

eral techniques, papers, sizes, borders and matts to achieve an optimal result.

Though most prints are either presented in frames behind glass, often reducing the visual appeal of a truly fine-art paper, you should very carefully select that printing paper. Take your time, and do some experiments to select the right paper for your prints. Paper with its tactile essence can be very sensual.

Try to match your paper, its color, surface, texture and gloss to the kind of print you make, to the subject of your image and the kind of feeling you wish to express. An architectural shot may want a different paper than a photo from nature, a black and white print a different paper than a colorful print, a print displayed without glass covering and a framed print behind glass.



Camera: Nikon D2X

Both authors use digital cameras – Uwe Steinmueller in a very professional way and Jürgen Gulbins as a serious amateur. They were both led to fine art printing by the desire to control their workflow from start to finish, from the shooting of photos to the finished print. Printing with a fine art printer, for them, is no simple, tiresome task, but the final step – a very important one – toward a pleasing image.

Planning for printing and printing itself takes time, but, in most cases, only a perfect, finished print gives full value to a good shot. Normally, only very few of all the photos you take will make it into a perfect, fine art print, but in many cases, this print will be the ultimate crowning of your photographic shooting. With the techniques shown in this book (together with others books we have published), you should be in complete control from the start to the very end of the process.

We hope that the control of this process and the creative tasks along the way, give you the same satisfaction and relaxation we found while doing it. Producing a satisfying print from your work has similarities to Christmas: the work is finished, and the present is unwrapped. You must still find a place to keep or present it, a place where you it can be enjoyed for years to come.

Matting, framing and hanging of prints is its own subject, and we go into it only briefly. We do, however, give some advice on how to keep and store your prints

Acknowledgments

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Last but not least we want to thank Bill Horton for correcting our texts.

Uwe Steinmueller, San Jose (California) March 2006
Jürgen Gulbins, Keltern (Germany)

Chapter 1

Printing Techniques

Camera: Nikon D2X

There are various methods of printing your own photographs. We go into deeper details with only one method – printing using inkjet printers. In this chapter, we take a glance at different printing methods and discuss which are good and why. Most are not recommended for fine art printing.

The special focus of this chapter – as is the focus of the entire book – is fine art printing, and the targeted user is the ambitious amateur, as well as the professional photographer. There are many reasonably good books on prepress work and commercial printing of books, magazines, brochures or posters using offset printing, silk-

screen printing, rotogravure or intaglio printing. We do not cover these methods, as they are either too complicated or too cost-intensive for the client we target. Nor do they deliver the kind of quality that may be achieved with today's photo inkjet printers.

1.1 Basic printing techniques

The journey from a pixel to a printed point

In image processing, there are many terms used having a similar meaning and often used interchangeably for image and print resolution: **dpi** (*dots per inch*), **ppi** (*pixel (or points) per inch*), **lpi** (*lines per inch*). Apart from this, the resolution of an image is stated by its dimensions in pixels or in inches (at a certain ppi or dpi resolution). So let's try to clean-up this mess:

When an image is captured by a camera or scanner, the result is a digital image consisting of an array (rows) of separate picture elements (called pixels). This array has a horizontal and vertical dimension. The horizontal size is defined by the number of pixels in a single row (say 1,280) and the number of rows (say 1,024), giving the image a horizontal orientation. That picture would have a 'resolution' of '1,024 × 1,280 pixels' (yes, some years ago, there were digital cameras around with such a resolution).

This not a physical size, yet. You could, for example, display this image on a 17" display (it would comfortably fill most such displays with each pixel of the image representing one pixel of the LCD monitor). It would probably have a display dimension of roughly 13.3 by 10.6 inches (a 17" display is diagonally roughly 17 inches). If you display this same image on a 19" monitor, its displayed size would be approximately 14.8 by 11.9 inches.

The size of the image displayed is dependent on the number of pixels the monitor displays per inch. The 'pixel per inch' resolutions (ppi) of monitors vary, and are usually in the range of 72 ppi to 120 ppi (the latter, larger 21.4" monitors). In most cases, however, with monitors the resolution is given as the number of pixels horizontally and vertically (e.g. 1,0240 × 1,280 or 1,280 × 1,600). So the 'size' of an image very much depends on how many pixels are displayed per inch. Thus, we come to a resolution given in 'pixels per inch' or ppi for short.

With LCD monitors, their ppi resolution is fixed and can't be adjusted (at least not without a loss of display quality). With CRT monitors you have more flexibility (we won't go further into this).

When an image is printed, its physical size depends upon how many image pixels we put down on paper, but also how an individual image pixel is laid down on the paper.

How image pixels are reproduced by printer dots

There are only a few printing technologies where a printer can directly produce a continuous color range within an individual image pixel printed (e.g. dye-sublimations, rotogravure and lightjet printing). Most other types of printers reproduce the color of a pixel in an image by approximating the color by an $n \times n$ matrix of fine dots using a specific pattern and a certain combination of the basic colors available to the printer.

If we want to reproduce a pixel of an image on paper, we not only have to place a physical printer's 'dot' on paper, but also have to give that 'dot' the tonal value of the original pixel. With bi-tonal images, that is easy. If the pixel value is 0, you lay down a black printed dot, and if the pixel is 1, you omit the dot. However, if the pixel has a gray value (say 128 out of 256), and you print with a black and white laser printer (just to make the explanation a bit simpler), we must find a different way. This technique is called *rasterization* or *dithering*.

To simulate different tonal values (let's just stick to black and white for the moment), a number of printed dots are placed in a certain pattern on the paper to reproduce a single pixel of the image. In a low-res solution, we could use a matrix of 3 printed dots by 3 printed dots per pixel. Using this scheme, we could produce 10 different gray values, as may be see in figure 1-1:

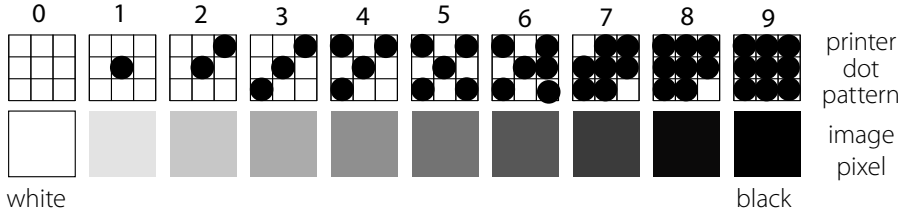

Figure 1-1: Different tonal values simulated by a pattern of singe printed dots

Using more printed dots per image pixel, allows you more different tonal values. With a pattern of 6 × 6 dots, you get 37 tonal grades, with an 8 × 8 pattern, 257 tonal grades (which is sufficient). For a better differentiation let's call the matrix of printer dots representing a pixel of the image a *raster cell*.

Now we see why a printer's 'dot per inch' (dpi) resolution has to be much higher than the resolution of a display (where a single dot on a screen may be used to reproduce a single pixel in an image, as the individual screen dot (also called a *pixel*) may have different tonal (or brightness) values.

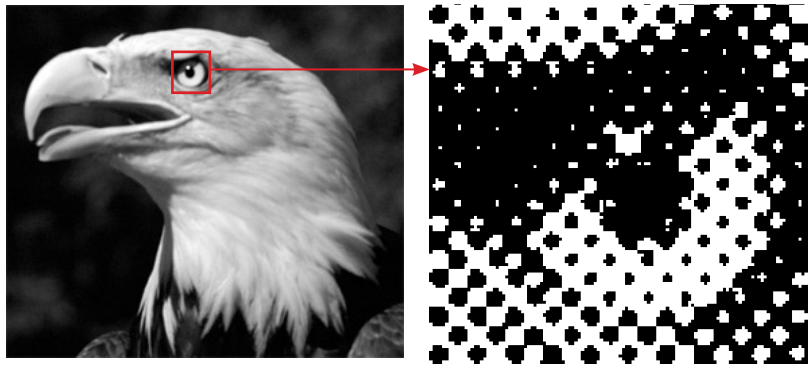

Figure 1-2: Enlarged printing raster of the eagles eye in a printed image

When you print with a device using relatively low resolution for grayscale or colored images, you must make a tradeoff between a high resolution image (having as many 'raster cells per inch' as possible) and larger raster cells providing greater tonal value per cell.

The image impression may be improved when the printer is able to vary the size of its dots. This is done on some laser printers (e.g. HP calls the technique *ProRes* on laser printers or *PhotoREt with inkjet printers*), as well as, with some of today's photo inkjet printers. If the dot size can be varied (also called *modulated*), fewer numbers of dots (*n* x *n*) are needed to create a certain number of different tonal values (which results in a finer raster). You may achieve more tonal values from a fixed raster cell size.

There are several different ways (patterns) to place the single printed dots in a raster cell, and the pattern for this dithering is partly a secret of the printer driver. For example, you get a more photo-like print, when the pattern is not the same for all raster cells having the same tonal values, but is modified from raster cell to raster cell in some random way (this is called *stochastic dithering*).

What are 'lines per inch'?

Using the technique described here to simulate different tonal pixel values, the rows of dots are not laid down exactly one below the other, rather the rows are slightly offset from one another. The macro-dots form a sort of line across an area. Raster cells and lines are not directly placed adjacent to each other, but have a slight gap (in most cases).

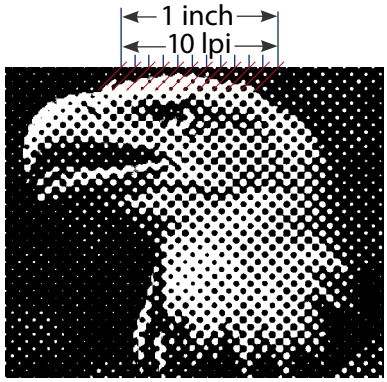

Figure 1-3:
Enlarged version of very coarse raster of 10 lines per inch.

In black color, these lines are normally placed at an angle of 45°. The number of raster cells or lines in one inch (see figure 1.3) defines another kind of resolution called '*lines per inch*' or lpi for short (using metric names it becomes '*lines per cm*' or 'l/cm' for short). When printing in color, a raster cell not only consists of a single color pattern, but the pattern process is repeated for all the basic (primary) colors found in the print.

Most color printers use Cyan, Magenta, Yellow and Black as their basic colors (also called *primary colors*). Some printers (and almost all inkjet printers, that are titled *photo printers*) use some additional basic colors to achieve a richer color gamut and a finer raster, yet, basically, they use the same scheme as printers using only four basic colors. In color printers, the simulation of tonal values is represented using a pattern of primary colors (see figure 1-4).

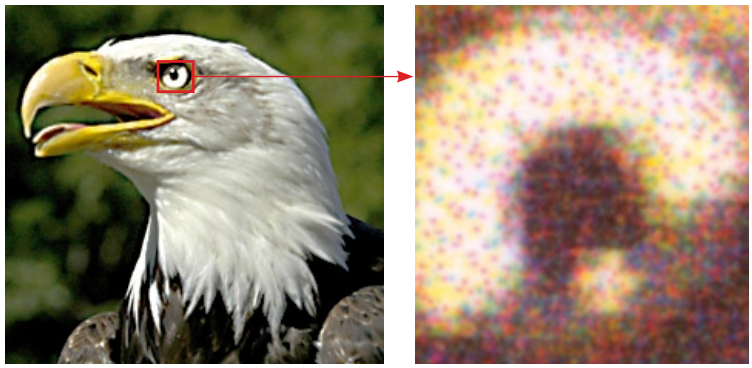

Figure 1-4: When printing color images tonal values (in inkjet and offset printing) are produced by a dot pattern of tiny colored ink dots

Different basic/primary colors (in a CMYK print there are four), raster cell lines are printed by using different line angles. In a normal CMYK print, those encountered in most colored books and magazines, Cyan is printed at 71.6°, Magenta at 18.4°, Yellow at 0° and Black at 45°. Other combinations are used, as well, but this is the common way to place lines of colored raster cells. To avoid moiré patterns stemming from overlapping rasters, line frequencies of colors vary slightly. Table 1.1 shows an example for a 106 lpi color raster.

Table 1.1: Example of a color raster using 106 lpi basic raster frequency

	Cyan	Magenta	Yellow	Black
lpi	94,86	94.86	100.0	106.0
angle	71.56°	18.43°	0.0°	45.0°

The number of lines per inch of a print depends upon

1. the number of tonal values one wants (more tonal values require larger macro-dots as more printed dots are required to provide broader tonal values),
2. the size of the individual printed dot (the smaller the individual printed dot, the smaller the raster cell may be) and
3. the paper used. If you use newsprint paper, which is very absorbent to ink, you would use a wider raster cell spacing to avoid the single macro-dots merging into one another. Using coated paper, raster cells may be placed closer together resulting in a finer printing raster and finer image impression.

Table 1.2 provides a guideline at which resolution in pixels per inch and lines per inch is appropriate for different printing methods.

Table 1.2: Recommended raster frequency for different printing situations

Raster width		Usage	image resolution
53 lpi	21 l/cm	Laser printer (600 dpi, 65 grey levels)	70–110 ppi
70 lpi	27 l/cm	Newspaper print, typical rough paper	90–140 ppi
90 lpi	35 l/cm	Good quality newspaper print	140–180 ppi
120 lpi	47 l/cm	Acceptable quality for books and magazines. Raster cells points can stills be seen.	160–240 ppi
133 lpi	52 l/cm	Good quality for books an magazines. Raster cells points can still be seen.	170–265 ppi
150 lpi	59 l/cm	Good offset or silk printing, individual raster point may hardly be recognized	195–300 ppi
180 lpi	70 l/cm	Good offset and silk printing, very fine raster, individual raster point hardly recognizable; good inkjet printing, individual raster point no longer recognizable at a reading distance of 20–30 cm (9–12 inches)	250–360 ppi
200 lpi	79 l/cm	Very good book prints, you need a very smooth paper for printing. Raster cells point hardly recognizable.	300–400 ppi

When you do fine art printing using an inkjet printer, you do not have to concern yourself much with raster line width. The dithering pattern of your printer driver is more complex than just described. Don't worry. Learn the native printing resolution of your specific inkjet printer – usually between 240–360 ppi and scale (up- or down-size) your image to that size. The values do not have to be precise – close is good enough. In most cases, the printer driver (or Photoshop) will do the proper scaling when using a value close to the printer's native resolution. Using a modern inkjet printer, you need not bother much with color raster angles. This, too, is taken care of by the printer driver or the RIP (see chapter 6). Inkjet drivers do not offer settings for raster width or color raster angles. For offset printing, however, this may (in very few situations) be of interest and may be dealt with in Photoshop when separating colors.

How many pixels or dots per inch do you really need?

There is no quick, general answer to that question. As often happens – it depends. It depends on several factors:

- **Kind of printing technique used:**
  Are you using a continuous-tone printing method (such as lightjet or dye-sublimation printing) or a method that produces halftones by dithering (such as inkjet or offset printing).

  The ppi values you need will be roughly the same for both methods, however, the dpi values of the printers will have to change, as in dithering, you need several printer points (or ink droplets) to build up a raster cell reproducing a pixel of the image.

- **Kind of paper used:**
  If you use a rough, absorptive paper (e.g. as used in common newspapers), printed dots will bleed a bit and you must reduce the dots per inch frequency (as indicated in table 1.2). If you use a good, smooth coated paper, you may increase your resolution and get a finer, more detailed image.

  If you use glossy or luster paper, you will be able to reproduce even more details (allowing for higher ppi/dpi) than with matte paper or canvas.

- **Viewing distance:**
  Viewing distance is an important factor, as the human eye can only differentiate single points up to a certain viewing angle (about 1–2°). If the viewing angle is less, two separate points can no longer be differentiated and visually merge. For a 'normal reading distance' of about 12 inches (30 cm), this minimal size is about 0.08 mm (0.0032 inch). Bright light may reduce this size a bit, low light increase it a bit. Consequently for an A4/letter-sized photo, a pixel size or raster cell size of 0.08 mm is a good value (equivalent to a 300 ppi raster size). If the pixel size is smaller, visual image quality (in terms of visual differentiation of details) will not substantially improve.

  If the photo is of ledger/A3 size, viewing distance is usually increased (in order to see the whole image at a glance). Thus for A3/ledger, the pixel size (or cell size if we use a dithering method), may increase the (raster) point size to 0,122 mm or about 210 ppi.

  If you produce posters, the viewing distance will increase further, and the pixel size may increase accordingly (and the ppi

may decrease accordingly). If you move up to large-format printing, your ppi may even go as low as 10–20 ppi – viewing distance will usually be more than 10 yards (or meters). In a simplified formula, simply divide 300 into your viewing distance in feet and you have the required ppi value or

$$\textit{resolution}\ (\text{in ppi}) = \frac{300}{\text{viewing distance (in feet)}}$$

For this reason, a photo shot with a 12 megapixel camera may be enlarged to almost any size you want – **if the image is viewed from the appropriate viewing distance.**

- **Kind of printer driver, driver settings and interpolation used:** For optimal results, you should use a ppi value close or even exactly that of the printer's native resolution. The printer's native resolution varies from manufacturer to manufacturer. Epson inkjet printers, for example, usually have a 'native resolution' of 720 ppi, while most HP inkjet printer use 600 ppi. Canon inkjets usually use 600 ppi, as well.

  Do you really need an image resolution as high as stated? It contradicts a statement given before. Well, yes and no. For optimal results with an Epson inkjet printer, use either 720 ppi or 360 ppi; for an HP printer, either 600 ppi or 300 ppi (here, we assume, no further scaling is necessary).

  You may leave (automatic) scaling either to Photoshop (as part of the print dialog) or to the printer driver. However, in both cases, you really can't know exactly which algorithms are used for scaling and how well those algorithms will work with your image and your scaling factor (Photoshop will use the scaling algorithm you set in your basic Photoshop Preferences).

  If your image is close to the native resolution given above (at the size you intend to print the image), the algorithm will not matter too much. If, however, the image has to be down-sized or up-sized considerably, the scaling algorithm does matter (it will also influence the effect of sharpening done for printing). In this case, you should either scale an image before calling up the print dialog (and you may have to do this for each individual printing size of the image) or you may use a RIP (see chapter 6).

  If you do your scaling in Photoshop, we recommend 'Bicubic Smoother' for up-sizing and 'Bicubic Sharper' for down-sizing.

1.2 Offset printing

Offset printing is the technique used for most books, brochures, magazines and newspapers. It is plate-based printing. The image is rasterized – as described under '*Basic printing techniques*' – for the print and transferred onto a printing plate. This projection currently is done with lasers or LED arrays. First, a plate is coated with a light-sensitive layer. The laser inscribes the image pattern onto this layer. Then, the printing plate is chemically developed. Those parts of the plate not printed are smooth and do not pick up water and ink when passing the wetting roller ①. When printing, the parts to be printed are rougher and pick up ink when passing an ink-soaked roller ②. This ink-pattern is transferred (by offset) to another rubber-coated rotating cylinder ④ (this is why the printing techniques is called 'offset printing'). The paper to be printed passes between this rubber cylinder and a another roller ⑤ pressing the paper against the rubber cylinder. Thus, ink is transferred onto the paper and the image is transferred, as well. In color printing, this process is repeated in additional printing units – one for each primary color (normally C, M, Y and K).

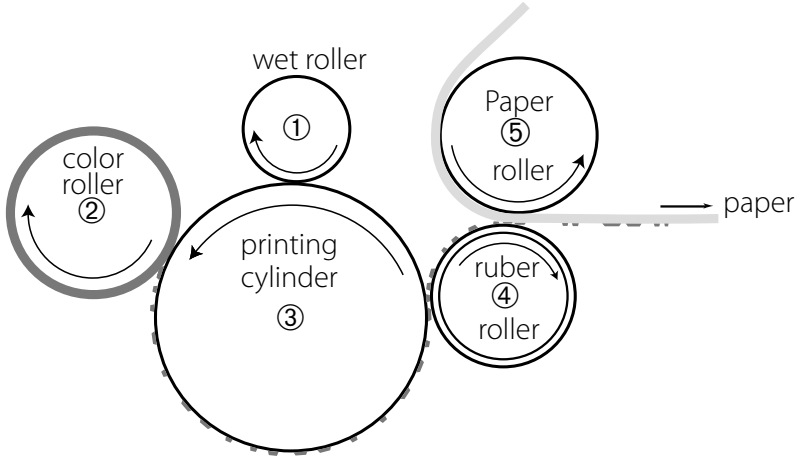

Figure 1-5: Functional model of offset printing (traditional analog offset printing)

The image quality achieved with this technology is quite good in terms of resolution and longevity – provided a good, coated, acid-free paper is used and the image is viewed from a correct (reading) distance. The richness of the color gamut is clearly below that of good photo inkjet printing (see figure 1.6).

The gamut of an offset print may be enhanced if six rather than the normal 4 (CMYK) inks are used. Printing with six inks is also called *hexachrome printing* (in addition to CMYK, Green and Orange are used). This, however, requires special printing presses having additional print units. Hexachrome printing is far more expensive than CMYK (4-color) printing, and also requires a special color separation process and special plug-ins for Photoshop to prepare images or DTP documents).

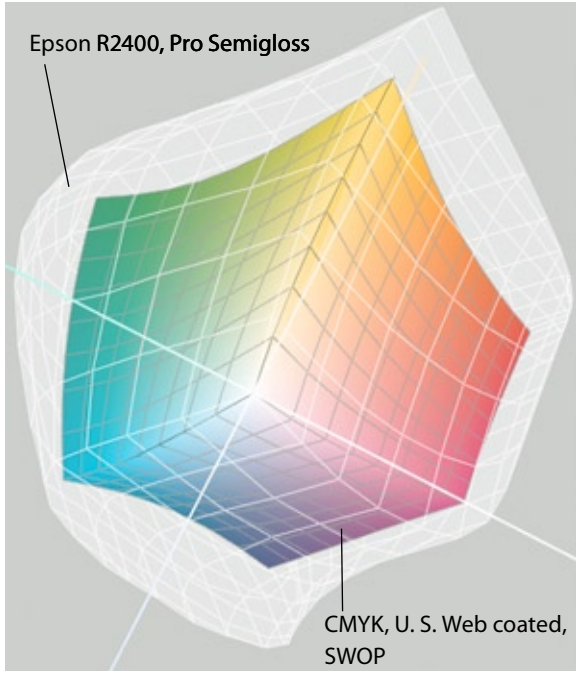

Figure 1-6:
The gamut of an photo inkjet printer (grey cover) is larger than the gamut with traditional analog offset printing (colored form).

Traditional offset printing might be considered if you intend to make a print run of 1,000 or more copies. As few, if any, home-user or small office can justify printing equipment for offset printing, we will not discuss it any further (additionally, we have a very limited knowledge of techniques involved).

In recent years, digital offset printing has come onto the market (e.g. HP Indigo press). These systems work with printing techniques similar to that of laser printers. These digital offset printers are mainly used for smaller print runs (typically 50–1,000). With most models, the maximum print size is restricted to A4 or A3. The resolution of digital offset printing is greatly inferior to that of analog offset printing (e.g. HP Indigo press 5000 has a resolution of 812 × 812 dpi, while analog offset printer work with typically 2,400 × 2,400 or even

3,200 × 3,200 dpi). Printing photos, this leads to a visible reduction of image quality. As for color gamut, some digital offset printers exceed the gamut of traditional CYMK offset presses. They, however, are still not adequate for high-quality fine art prints.

Traditional offset printers, as well as, digital offset printers are quite fast. HP, for one example, gives a printing rate of about 4,000 A4 pages per hour for its HP Indigo press 5000. The speed of traditional offset printing presses may exceed 100,000 pages per hour.

The costs of digital offset printers starts at about 50,000 $ US and up. The price of a traditional offset press may easily exceed 1 Million dollars.

1.3 Laser printers

Laser printers are well established, reasonably fast (from 4 pages per minute up to 100 pages per minute) and reasonably inexpensive as to the cost per page (typically about 4–6 cents per A4/Letter page in B&W at an ink coverage of 5% per page and about 16–20 cents at an ink coverage of 90% per page). While color laser printers were quite expensive formerly, in 2004 and 2005 their price dropped dramatically. You can buy a color laser printer for less than 500 $ US currently. With low-priced color laser printers, manufacturers use a business model similar to low-cost inkjet printers: they sell inexpensive printers and earn their return via rather expensive toner units. A color toner set – lasting for about 3,000–5,000 pages at 5% medium ink page coverage – costs about the same as the basic laser printer unit (300–400 $ US), resulting in a cost per page (A4/letter) of roughly 0.1 $ US with a 5% medium ink coverage per page and about 1.6 $ US when printing full page size colored images. Nevertheless, printing of text and graphic pages with a color laser printer is much faster and somewhat cheaper than using an inkjet printer.

Laser printers use very much the same technique (see figure 1-7) used by modern photocopy systems (some models even combine both functions: scanning and printing):

A photo drum ① is charged positively by a charging unit ②. The image of the print is rasterized by the printer's RIP (*Raster Image Processor*), and this raster is applied onto a drum using a laser beam and rotating mirror ③ (or alternatively by an array of LEDs). Where

the light hits the drum, the positive charge is erased or the surface is charged negatively. Then, the drum passes the toner unit ④. Those parts that saw light pick up the positively charged toner, while those parts that bear a positive charge reject the toner. Further on, the toner is transfused onto the paper and burned in by a heated roller (fuser) ⑤. Instead of a laser and a rotating mirror, some printers use an array of LEDs for discharging the drum.

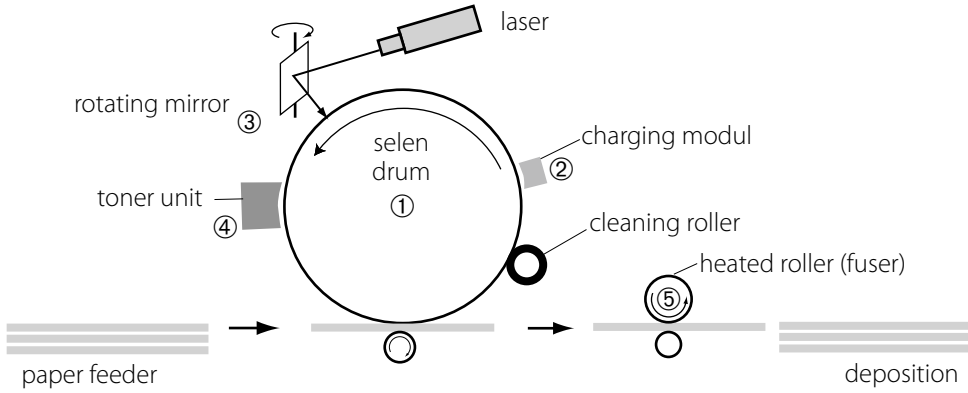

Figure 1-7: Functional model of a laser printer

Color laser printers use four inks – Cyan, Magenta, Yellow and Black (CMYK). They either use four drums or a transfer belt, that picks up toner from four separate drum rotations and four toner units and transfers the complete color image onto the paper with one rotation.

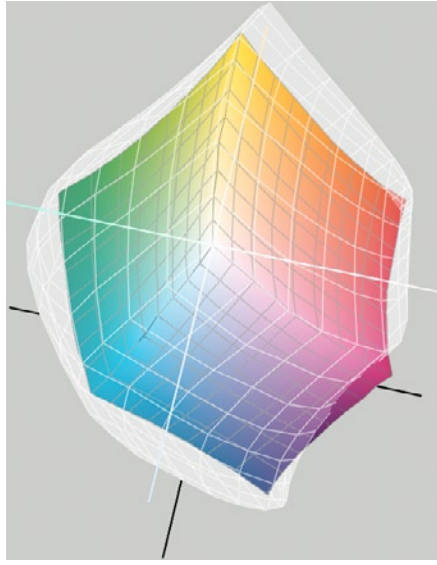

Figure 1-8:
*Gamut comparison of a color laser printer (**OKI C5400**) **(inner colored** figure) and a photo inkjet printer (**Epson R2400, using Epson Pro Luster** paper, outer gray cover).*

As for image quality, the limiting factor of today's color laser printers is the resolution used (600–2,400 dpi, usually just 600 or 1,200 dpi) and the number of colors they use – which is only four (CMYK). A further limitation stems from the size of the toner particles, much larger than those of dye-based or even pigment-based inks on inkjet printers.

Most laser printers have problems producing homogeneously colored areas or fine tonal gradients (you usually see smaller blotches of unevenly printed colors). With several of the color laser printers, the image shows a gloss, which may impair viewing with some images. You cannot avoid the gloss even when using matte papers. This is especially true for solid inks used by some XEROX color laser printers.

For this reason, image quality with color laser printers is clearly inferior to all other printing methods described here and can't touch that of photo inkjet printers. If, however, you have a color laser printer, we recommend using it for fast index printing. The color and detail quality, in most cases, is good enough for a first, fast inspection.

Image longevity very much depends on the type of paper and inks (toner) used and ranges from about 10 to 20 years. The permanence of black & white prints is much better, and may be used for archiving documents (provided you use the appropriate paper).

1.4 Dye-sublimation printers

Thermo-sublimation printers are frequently used for the fast and simple production of photographic prints, often directly from the digital camera via a USB cable using the DPOF (*Digital Print Order Format*) or PictBridge protocol supported by today's digital cameras – even the cheaper consumer models. Alternatively you may plug your camera's memory card into a card-slot the printer provides.

With thermo-sublimation printing (also called *dye-sublimation* or *dye-sub* for short), color is transferred from a color-coated ribbon (foil) onto the paper. The transfer is done by an array of tiny heating elements (integrated into the print head). Where the ribbon is heated, the color on the foil evaporates (sublimates) and enters the paper where it cools down. CMY as well as CMYK ribbons are used. Three or four passes (or sections) of colored ribbons are needed to

produce a complete image on the paper. Usually the ribbon consists of sections with the alternating basic colors (three for CMY or four for CMYK). The used portion of a ribbon becomes unusable, is rolled up and finally discarded. The paper must make three (CMY) or four (CMYK) passes under the print head. Individual color intensity is determined by the amount of heat. When the next primary color is added (to those colors previously composed of several primary colors), their colors merge into a combined color due to the heat. The three or four colors merge in the paper and form an (almost) continuously toned color.

With these systems, production costs are independent of the number and kinds of colors and the amount of color a printed page has, as a ribbon section is used only once an then discarded.

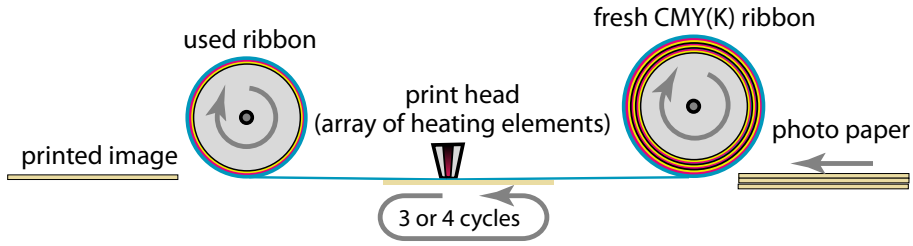

Figure 1-9: Working scheme of a thermo-sublimation printer

The typical resolution of dye-sublimation printers is 240–300 dpi, which sounds very low. However, keep in mind that dye-sub printers do not render a color via dithering, but do it by merging their basic colors by sublimation, thus achieving an (almost) continuous color tonal range for every dot and a highly photographic image at these resolutions.

Figure 1-10: Canon SELPHY CP600 dye-sublimation printer, 300 dpi, print-size up to 10 x 20 cm, (Courtesy Canon Germany)

Typical dye-sub printers today range from 4 × 6 inch to A4 in print size, the lower-cost models (partly portable) mainly in the 4 × 6 inches (10 × 15 cm) range. A typical print speed is about 30–100 seconds for a 4 × 6 inch photo. Some printers are much faster (e.g. Kodak Photo Printer 6850, 300 dpi, 8 sec. for 4 × 6 inch).

The range of printing material used with dye-subs is very limited and highly restricted to papers provided by the manufacturer of the printer – one kind for glossy and another kind for matte paper, in most cases. The same is true for inks (color ribbons).

The lightfastness and longevity of dye-sub prints is about 5–15 years (considerably more in dark storage).

Prices for small dye-sub printers start at about $ 120 US and go higher with print/printer size; about $ 500–1, 500 US for a letter/A4 size printer. The cost per print is about $ 0.20–0.30 for a 4 × 6 inch print and about 1.5–2.5 dollar for an A4/letter sized print.

1.5 Lightjet printing (digital photo print)

There are various names for this technique: *digital photo print* or *lightjet printing* (*LightJet* is a trade name of Cymbolic Science) or *direct digital printing*. Here, in essence, the image is imposed onto conventional photographic material by lasers. To produce an RGB print, three lasers are used. The material may be photographic paper also used for traditional color photos or may be photographic film for translucent prints. The exposed material is then developed in a traditional wet process. The resolution used by most printers is either 300 dpi (or ppi) or 400 dpi. Lower resolutions may be used, as well, and will be interpolated to the printers native resolution. This seems very low, compared to the resolution of inkjet printers or offset presses. With lightjet printing, however, no dithering is required to produce halftones, and every exposed dot on the paper combines Red, Green and Blue, thus resulting in (almost) continuous tone dots. For this reason, 400 dpi or even 300 dpi will produce a very fine image quality.

There are a number of different makers and models of this type of digital photo printer (e.g. Fuji Frontier minlab, Agfa D-Lab, Lambda, Océ LightJet®, Chromira). Print image size may vary from 4 × 6 inch up to 50 × 50 inches). With some digital photographic printers, you may

even go much larger (e.g. the Durst Lambda photo laser imager may produced prints up to a width of 50 inches and a length of 262 feet).

Figure 1-11: Durst Lambda® large-format photo laser imager (Courtesy Durst Phototechnik AG, Brixen, Italy)

As lightjet printers are quite expensive (they start from about 100,000 $ US and may go up even higher), this technique is almost exclusively used by service shops – often the very largest ones.

There are two kinds of photographic print shops:

1. **Consumer-oriented photographic print shops**
   They produce a very large quantity of prints per day at very low prices (typically from 15 cents for a 4 × 7 inch print to about 5 $ US for a letter sized print). The processing is done fully automatically and in large quantities. Special requests are usually not handled by these shops. In most cases, an automatic image optimization is performed. This may be disabled at most shops when you place an order (which you should do if you have done your own optimization).

   The quality of their prints is usually quite reasonable and uniform, in most cases.

   As of today, ICC profiles are ignored by these printers; all images are assumed to be in sRGB. If you send an image to them for processing, you should convert it to sRGB (if not already in this format).

   Most of these shops offer only standard image formats. If your image format differs from those supported, you have the option

of using either the full width with some parts of the image being trimmed off or receive an image with white borders – which, for fine art prints, may be what you want, anyway. In most cases, it is preferable to set your image to one of their standard formats and decide where and what kind of white frame (or other colored frame) you wish to use.

2. **Professional photographic service bureaus**
   They specialize in high quality prints (usually in smaller quantities); also accommodating special requests. They may even offer to optimize your image for printing – which may or may not be appropriate. These bureaus should provide you with a printer's ICC profile (often, you may download this from their web homepage). These profiles may be used for two purposes:

   A) Use as soft-proofing to assess how your image will appear when printed (see chapter 3.10).

   B) To convert your image to another profile. When you send your images to a service bureau, the image should be converted to the correct profile as other embedded profiles are ignored by the printing process. This hopefully will change some day in future!

Print permanence of digital photographic prints is that of photographic paper (silver-halide color prints), which typically range from 17 years (e.g. Konica Minolta QA Paper Impressa) to 40 years (e.g. Fuji Crystal Archive paper), depending on the kind of paper used. All these data assume that all the chemical residues are removed from the photographic papers. If not, its lifetime will be substantially reduced.

Most shops offer 3–4 kinds of paper (glossy, semigloss, pearl and matte). As standard photographic papers may be used for printing, there is sometimes a choice of several papers from different suppliers. For higher quality, often Fuji Crystal Archive paper is used due to its high print permanence.

Some digital photo printers allow printing on transparent and translucent photographic film.

Print speed is quite fast – at least compared to inkjet printers. The Océ LightJet 5000, for example, prints a 50" × 50" print at 405 dpi in about 12 minutes.

The Color gamut of modern lightjet printers is about that of Adobe RGB (1998) (slightly larger).

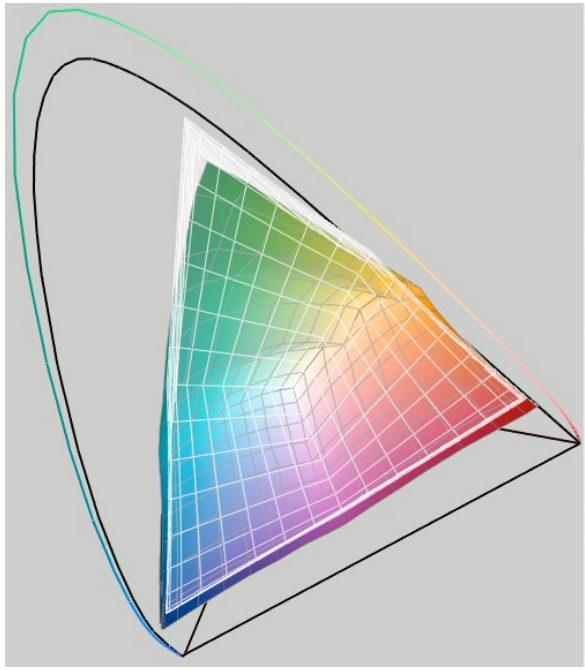

Figure 1-12:
Color gamut of Adobe RGB (1998) (white frame) and that of a digital photo laser printer (Océ LightJet 5000) (colored frame)

If you want to produce many prints of the same image with the papers offered and their lightfastness (print permanence) sufficient for your purpose, lightjet prints ordered via Internet may be an easy and cost-effective way to go.

Best to start with a test order, and only order more if the results are satisfactory. While with consumer photographic print shops you may have your pictures the next day (at least in Europe, where even snail mail is reasonably fast), prints from a professional service bureau usually take 3 to 5 days, plus delivery time.

1.6 Inkjet printing

Having taken a glance at other printing techniques, we want to dig deeper into inkjet printing. While some techniques mentioned are rather old, inkjet printing is rather young. The first color inkjet printers came to the market in about 1985. Compared to today's inkjet printers, they were very slow and showed really poor image quality. They were used largely to render simple color plots and production of transparencies for presentations. Print permanence of that first generation of color inkjet printers was quite poor.

Soon, however, some specialized high-end printers came on the market. The IRIS printer – made by IRIS Graphics of Bedford, Massachusetts (later acquired by Scitex) – was one such machine. The IRIS printer, at an early stage of inkjet history, provided a reasonably high print speed and considerable resolution and image quality, while print permanence and maintenance were problems. Prints produced by IRIS printers are sometimes called *Giclée prints*.

Along with the growth of the PC and Macintosh markets, the need for inkjet printers grew, and today you scarcely find a home PC without an inkjet printer, their cost dropping from several thousands of dollars US to about 150–800 dollars (depending on the maximum print size) for quite acceptable desktop photo inkjet printers, currently. For large-format inkjet printers (those beyond a print size of A3+/Super B), you will have to spend several thousand dollars.

Inkjet technology

There are a number of different inkjet technologies in use. The basis of all of them is that tiny ink droplets are ejected from a printhead and projected onto a paper. To increase print speed, a printhead now consists of many nozzles – up to about 180–500 per color on contemporary printers.

The technique making the ink droplets eject differs with various printers and printer makers (most printer manufacturers use a single technique in all machines).

The main techniques are:

- Continuous flow inkjet printers

The following methods are also called *drop-on-demand*, as they eject a droplet only when needed on the paper:

- Thermal inkjet printers (e.g. used by most HP and Canon printers). Canon calls this technique *bubble-jet*.
- Piezoelectric inkjet printers (e.g. used by most Epson printers)

Contiguous flow inkjet

This technique was developed by IBM in the 1970s. With continuous ink flow systems, a continuous stream of charged ink droplets is produced. Those droplets intended to print fly straight onto the paper, while charged droplets are electronically deflected into a gutter for recirculation. This is the oldest inkjet technology and is used for high-speed production lines. The complex ink-circulation system makes these printers costly in maintenance. They can be very fast compared with the typical drop-on-demand type printers.

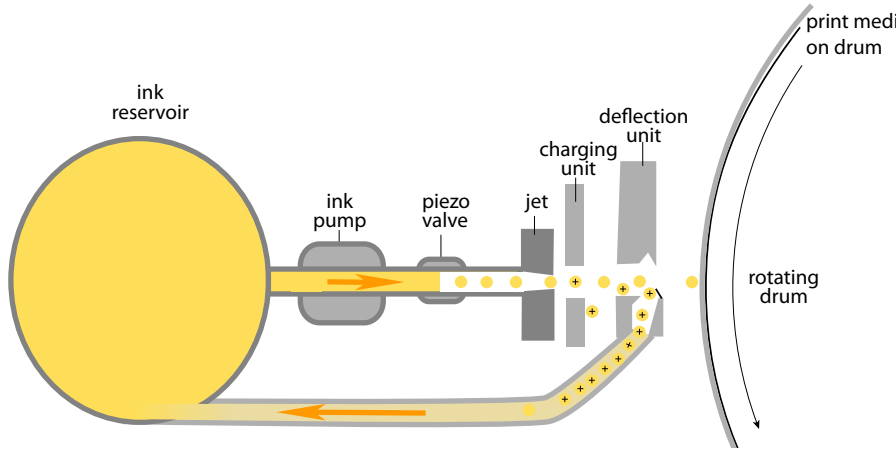

Figure 1-13: Principle ink flow in a continuous flow inkjet printer

This technique is used by the famous IRIS inkjet printer, where the paper is mounted on a rotating drum. These systems are quite expensive and not suited for desktop usage or smaller installations. Usually solvent-based inks are used with these printers.

Piezo inkjet

Certain kinds of crystals expand or contract when subjected to an electrical charge. This effect is used in piezoelectric inkjet printers. To eject a droplet, an electric pulse is applied to the crystal in the print head, the crystal deflects inward, forcing a droplet out of the nozzle. The returning deflection sucks up fresh ink from the reservoir and the cycle repeats. A print head consists of many of these miniature jets (nozzles), and the system allows varying the size of droplets to produce a finer pattern and smoother color gradients.

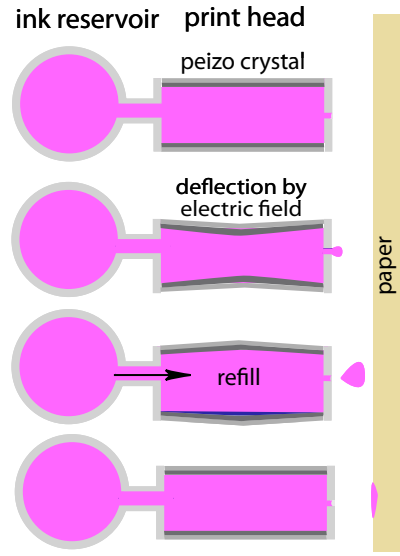

Figure 1-14: Different phases of the ejection of a droplet with a piezo print head

Thermal inkjet

With thermal inkjet printing – also called bubble-jet printing – there is a resistor in the print head chamber. When it is heated by a short pulse of electrical current, a vapor bubble forms in the chamber increasing pressure. This pressure forces an ink droplet out of the nozzle. Then the bubble collapses and draws in more ink from the reservoir. For the next droplet, the cycle repeats. This technique is used by some HP printers (e.g. HP Designjet 30), as well as by most Canon printers (e.g. Canon i9900, W6200). Also some wide-format printer like the HP Designjet 130 and the ENCAD Novajet 1000i use thermal print heads. The technique may be used with dye-based, as well as, pig-

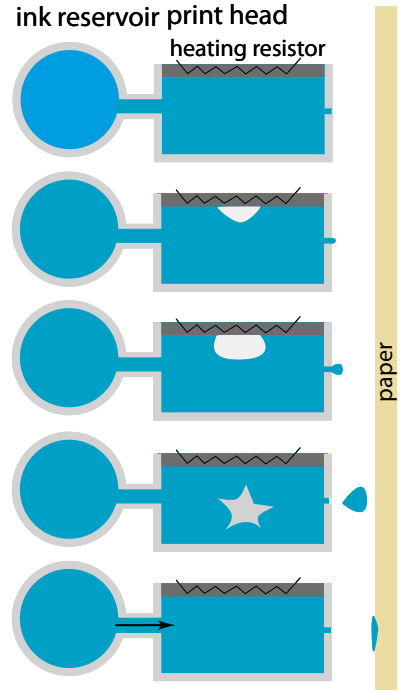

Figure 1-15: Phases of an thermal inkjet printer

ment-based inks, however, it does require an ink suited for thermal inkjet printing (with a low boiling point). The life-cycle of these printers is a bit shorter than that of piezo-based print heads, but the production cost is lower.

Droplet size

Along with increasing printer resolution, the size of the individual ink droplets has decreased. A smaller droplet allows production of a finer raster of dots on the paper. Today, photo printers use a droplet size down to 1–5 picoliter (1 picoliter is 0.000 000 000 001 liter or 1×10^{-12} liter), thus allowing a single pixel (a raster cell) of your image to be built by many tiny dots, achieving a very fine raster (e.g. 360 ppi or even 600 ppi) with a broad range of tonal values.

With some photo inkjet printers (e.g. with piezo-based ones) the droplet size can vary. For dark colors – especially colors of a primary ink color – larger droplet sizes are used. This allows increasing print speed. For light colors, a smaller droplet size and wider droplet spacing is used.

Printer resolution

When inkjet printers first arrived, a resolution of 150 dots per inch was considered good. Nowadays, resolutions of 2,400 dpi, 4,800 dpi, 5,800 dpi, even 9,600 dpi are normal for photo printers. To be honest, the higher resolution claims in advertising are a bit misleading. First of all, such high resolution is only achieved in one direction. Canon, for example, with it i9950 photo printer has a maximum resolution of 4,800 x 2,400 dpi, where the higher resolution is seen in the horizontal direction (covered by the horizontally to and fro moving print head) and the lower resolution in the vertical direction. Here, the increments are determined by the tractor moving the paper step by step. The same is true for most inkjet printers.

Whether you really need the maximum resolution of today's machines when printing is quite a different question. To be able to use the maximum resolution, you need a paper or other printing media that can accommodate the fine pattern of ink droplets, so the ink will not leak too much into the open area. The paper (or its coating) must absorb ink very quickly to keep it localized. Be certain your paper is specified for the resolution you wish to use.

From our experience, a (horizontal) resolution of 1,400 dpi or 2,800 dpi (typical resolutions used by Epson printers) is sufficient – even for critically fine art prints. Often, when higher resolutions are used, the print speed drops dramatically and ink usage increases without resulting in significantly better image quality. This does depend on the individual printer.

Number of inks

While inkjet printers originally used a single black ink, three more (CMY) were added, then four (CMYK). All of today's photo inkjet printers use at least six inks: CcMmYK (c = light cyan, m = light magenta).

To enhance the gamut of these printers, more inks are added. Epson's Stylus Photo R1800, for instance, additionally uses Red and Blue (and, optionally, a gloss optimizer) but has no Light Cyan nor Light Magenta. Epson's R2400 uses three shades of black inks: a Photo Black (or alternatively Matte Black), a *Light Black,* as well as, a *Light Light Black* in addition to the CcMmYK, thus adding up to eight inks. This collection of inks allows producing neutral B&W prints with very fine tonal gradients.

Today's professional and semi-professional inkjet printers surpass silver halide prints (traditional photo prints) concerning color gamut as well as print permanence.

The weak spots concerning the color gamut of many of today's photo printers are saturated blue and red. For this reason, the number of different inks used in a fine art printer will likely increase – we expect 11 inks before long (C c M m Y K lk llk R B and, optionally, a gloss optimizer).

The number of inks that may practically be used is limited by the weight and size of the print heads (heavier usually implies slower head movements) not to mention the cost of the numerous ink cartridges.

Type of inks

With today's normal inkjet printers mainly two types of inks are used:

- dye-based
- pigment-based

There are , however, several other types of inks on the market – e.g. inks with an oil-base – mainly for large-scale printing and prints for

use outdoors. Other inks are dedicated for printing on fabric (cloth) and are usually solvent-based. Some printers use hybrid inks – dye-based ones for colors and pigment-based ones for black to achieve a dark, deep black (this for example, is used by some Canon printers).

For more details on dye-based and pigment-based inks see chapter 2.

1.7 Other printing techniques

There are many other printing techniques available, and some of them may be suited for fine art printing. Screen printing (or silk-screen printing) is one. There is also solid ink printing (used by some Xerox Phaser printers), thermoautochrome printing and various other techniques. But these are either not practicable for home-based printing, being too expensive, too voluminous or time-consuming. These techniques may be viable for a service bureau – especially when intending to produce a large quantity of prints of the same image and/or want to print at a larger size. In these cases, you should ask the service bureau for specific details on how to prepare your images for printing.

1.8 How to pick your fine art printer

The inkjet printer market is really huge. So, how do you pick a suitable printer for your needs?

Though it may appear trivial, the first question is: What do you intend to do with your printer? As you are reading a book on fine art printing, you probably want to do fine art printing – or at least print your images – probably photos – at high quality. This narrows the field substantially.

First, let's define what the requirements for fine art printings are:

- High to very high image quality
- Rich color gamut
- Reasonable print permanence (more than 20 years)
- Adequate print size and print performance
- Costs

Image quality

When photos are printed, you should achieve a clearly photographic image (provided you use the proper paper, e.g. Glossy). Tonal gradients should be very smooth and should show no banding. The individual pixel (raster cell) should not be visible at a proper viewing distance. Almost all of today's photo inkjet printers providing print resolutions beyond 1,200 dpi and having more than the basic four inks (CMYK) achieve this goal. There may be variations concerning the types of inks used, which leads us to the next point.

Rich color gamut

As to the gamut – the spectrum of colors a particular printer can produce – dye-based inks tend to provide a larger range than pigment-based ones. The manufacturers of pigment-based inkjet printers try to compensate for this by employing new ink formulas. Epson, for example, in 2005, with its K3 inks, reached its third generation of UltraChrome ink. Additionally, more colors are used. Using more colors – beyond the basic CMYK sets – is the way all 'photo printers' evolve. Most of them use at least six inks (CMYK, c (light cyan) and m (light magenta). Some add red and blue, others add several shades of black. In 2006/2007, we will probably see printers using both CcMmYKRB and 2–4 black variations.

This race started, when in February 2006 Canon announced their new printer model PROGRAF iPF 5000, providing 12 inks: C c M m Y, R G B, Photo Black, Matte Black, Gray and Photo Gray.

With new ink formulas and more colors in use, the gamut difference between dye-based and pigment-based inks virtually vanishes, as of today. You may enhance the achievable gamut by using bright white glossy papers – enabling the maximum gamut. These papers are available for both kinds of printers/inks.

It's very difficult to interpret gamut size from technical specification of a printer. If the last bit of gamut size really matters, you will have to compare ICC profiles provided by the printer manufacturer (in many cases, you may download them from their home page). Using very white glossy paper, you usually achieve a wider gamut than using matte or slightly tinted papers.

Black & White printing

If you are looking for a printer to produce good B & W images – correct might be 'printing of monochrome images' – look for a printer with at least two shades of black ink (though with a good RIP like The QuadTone RIP or ImagePrint, you may compensate somewhat for fewer black inks). For some printers, there are also multi-tone black ink-sets. For the Epson 2100/2200, for one example, a number of multi-tone black-ink sets are on the market (e.g. MIS Ultra Tone family of inks [59] and Piezography Neutral K7 inks [45] or Luminos [47]). As you must carefully clean your print heads when changing from color to black-toned inks, a printer using multiple black inks in its original set would be preferred. The Epson R2400, using three different black inks (Black, Light Black and Light Light Black) or the HP 8450 and 8750, also using three black/grey inks, are examples of printers well suited for B&W printing.

With the introduction of printers using several shades of black ink, the importance of these third-party, multi-tone ink sets decreases. If the printer uses 2–3 toned black inks, its printer driver provided by the OEM usually has special settings for B & W printing.

Print permanence

A print should last for a reasonable time frame without noticeable degradation of color or density. The real question is 'What is reasonable?' This answer may vary greatly depending upon your own expectations, as well as, what you hope to do with the print. According to our definition, the print should have, at minimum, a print permanence of 25 years or longer. If you intend to sell your prints, 20 years may not be long enough – perhaps 50 years or even 100 years (e.g. for museums). You must define your own expectations.

You will find more on print permanence in chapter 2.1.

Adequate print size and print performance

Most images make an optimal impression when printed at an adequate size. While most desktop printers offer a maximum size of A4/Letter, for fine art printing a minimum size A3/Ledger is sensible. For some prints – especially for exhibitions – larger formats may be required. As prices increase considerably for larger format printers,

you might carefully consider what size is right for you. Staying with smaller format printers, you may still obtain the large format prints at a print shop (e.g. after having the basic print verified on your smaller printer).

Types of papers supported

Not every paper is suitable for every printer. You must match the paper to the printer – size-wise, ink-wise and paper-thickness wise. While size is obvious, the other two factors may not be. Most printers can only accommodate paper up to a maximum thickness. You can find this information from the technical specifications. Maximum media thickness is largely influenced by the path through the printer the paper will travel. The Epson R2400, for example, provides three different paper paths: the normal one, from the top, a second one using rear-feeding, and a third one where the paper is pulled in from the front and pushed off at the front again. This allows a paper thickness of up to 0.06 inch (1.6 mm) when using its straight through path. HP's Designjet 30, in comparison, allows only a maximum thickness of 0.02 inch (0.4 mm).

Looking further at these two otherwise similar printers, with the HP solution you are restricted to papers HP offers for this line of printer. If high lightfastness is an issue (in using HP papers, lightfastness is about 65–130 years (the latter for B&W prints), using different papers, print longevity may be shorter). For the dye-based inks of the HP DJ 30, you must use a special swellable paper (see chapter 2.3, page 2-20) when print permanence is an issue – which for fine art printers, it should be. This may not be a severe restriction as HP offers a number of different and reasonably-priced papers for this line of printers.

With the Epson R2400 (and printers of the same line) on the other hand, using pigmented inks, your choice of papers is much richer. Apart from many Epson papers, there is a variety of other third-party papers to use with this printer and its inks. Using pigment-based inks, you have greater freedom when choosing papers.

Some printers also accommodate roll paper. This can slightly reduce paper cost, but may become more important when you want to print panoramas or long flyers. When using roll paper, an automatic cutter is an advantage, however, mostly these are available for larger-scale printers.

Another point when looking into a printer is matching paper. Again, this is related to the ink set used. There are inks better suited for glossy and semigloss, while other inks work better for matte paper. To accommodate this, some modern photo printers allow switching some inks – usually the black ink cartridges (it would be preferable, if the printer could accommodate more cartridges instead of having to switch them physically).

So, for example, the Epson R800/R1800 using UltraChrome Hi-Gloss inks and an additional gloss optimizer targets gloss, semigloss and luster papers and is less suited for matte papers or canvas. You may, however, use either Photo Black (on gloss or semigloss) or Matte Black (for that matter) – depending upon the type of paper used. If you print matte, velvet or watercolor papers normally, the Epson R2400 is the better choice. Though, you may use either Photo Black for gloss or semigloss or Matte Black also on matte papers.

In general, dye-based inks are better suited for glossy paper, while pigment-based inks print better on matte papers (see chapter 2-2 for more on this).

Costs

There are three categories of costs to consider:

- The price of the printer
- Paper costs
- Operational costs – e.g. for inks, print heads, …

In printing, the price of the printer is often a minor part of total costs. Paper costs vary greatly depending on the size, type and brand of paper used and the quantity you buy. As a thumb of rule the price of an A4/letter size page will be 1–2 dollar and for an A3/leger size page will be 2–4 dollar for good quality fine art paper.

You may find a third party paper priced cheaper at Staples or Office Max and buy their in-house paper. But, you must ask yourself, "do they provide profiles for their papers? Do they offer a lightfastness statement?" Probably not. With papers for fine art printing stick to high quality inkjet papers from suppliers with a proven track-record. Everything else is often a waste of time and money (for inks). In chapter 2.3, page 2-29 we name a few papers we tested and liked. Some papers which give a fine print for B&W printing are named in chapter 7.4, page 7-12.

The most expensive part of fine art printing is probably ink – this is true for most desktop fine printers, while large-format printers have large ink cartridges resulting in lower ink costs per print (of a given size). Ink costs per print depend on:

- The size of your print (obvious)
- The kind of printer used
- The resolution used for printing.
  The higher the resolution chosen, the more ink is consumed. For this reason, check if the maximum resolution (or quality setting) really achieves a visible improvement. In our experience, resolution beyond 2,400 dpi uses up more inks without noticeably better image quality. Using some printers (and papers), you may even reduce resolution to 1,400 dpi.
- The kind of paper used. Some papers (for good image quality) soak up more ink than other papers.

You may slightly reduce ink consumption by avoiding unnecessary switching of the printer on and off. Each time you power up the printer, some ink is used for nozzle cleaning. On the other hand, you should activate the printer from time to time (once a week is an acceptable interval) and should operate (or nozzle clean) the printer periodically or its nozzles may clog, resulting in spending much ink for only nozzle cleaning. If you wait too long, you may even have to replace a clogged print head or two – clogged by dried up ink.

If you print often, it may be cost-effective to buy a larger printer (beyond the A3+ size), since larger printers often use larger ink cartridges, resulting in cheaper inks (look at the cost in dollars per milliliter). For example, with the Epson R2400 you pay about $ 1.0/ml ($ 14/13 ml), while withe the cartridges of the R4800, you only pay about $ 0.5/ml ($54/110 ml) or only $ 0.38/ml when using 220 ml cartridges.

Another way to reduce ink costs is to use third-party inks. For consumer A4/Letter-sized printers, there are many brands. Most of them will result in poorer lightfastness, but not true for all of them. Here, you may have a look at tests published by some PC and photo magazines. For A3 and larger professional printers, there are fewer offerings, however, some inks do offer reasonable quality.

A potential problem using third-party inks is that you may void your printer's warranty. You should clean the print heads thoroughly before changing ink brands. For this, there are special cleaning cartridges available. For the printers we discuss, there are OEM-compatible replacement cartridges that come rebranded. Some are original OEM cartridges refilled (ink counters reset). While a few of them are unsuited for fine art printing, some companies such as Phantone ([41]) or Lyson ([42]) claim high quality, good lightfastness and (that's why you do it) lower prices (for more ink suppliers see [43] – [46], [51], [52] and [57])).

A technique offered for many large-scale printers (but down to some A4/Letter-sized printers) are *Continuous Flow Ink Systems* (CIS or CFS for short) – also called *bulk ink systems*. This technique should not be confused with the continuous-flow printing technique (described at page 1-21) Here, the OEM ink cartridge is replaced by a different cartridge which is fed ink via a tube to a bulk ink bottle. These systems have two major advantages:

1. The ink per print or per milliliter is much cheaper than using OEM cartridges. For our previous example for the R2400, this is about $ 0.17/ml and with the Mediastreet Niagara II system, 4 or 8 ounce (118/236 ml) ink bottles are used. With larger printers and larger bottles it may even cheaper.
2. You may print much longer before replacing ink cartridges.

Figure 1-16: Panta Rhei continuous flow ink system (Courtesy Monochrom Germany)

A disadvantage is that you make a pre-investment (for the R2400 it would be about $ 335 for the Mediastreet system (with filled bottles) and – if you switch inks (e.g. Photo Black to Matte Black), you have a lot of ink used in cleaning out the tubes. Additionally, you must use auto-reset chips to fool the printer or cartridge. Additionally, you can't use the OEM original ICC profiles any longer but will need profiles reflecting the new ink. If you print a lot, this could be a minor problem. Some ink suppliers offer ICC profiles for their ink and various common fine art papers.

Now, how about lightfastness? Here again, you will find some ink manufacturers (e.g. Lyson), that refer to tests done by WIR ([60]).

More points to consider

There are a few other points you may want to consider when selecting an inkjet printer.

Printer interface

Some years ago, the standard interface for PC printers was the parallel port (Centronics or IEEE 1284) or serial format for Macs. This fortunately was replaced by USB 1.1 and more recently by USB 2.0 for most desktop printers. Some printers include an additional Firewire (IEEE 1394) interface. This could be an advantage when connecting the printer to two systems. Most large-scale printers also have a LAN (local area network) interface. This is useful if you want to print from several systems in a local network. A low-cost, small, print-server with a USB interface to the printer will achieve the same end and may be cheaper than an optional printer LAN interface.

PostScript RIP

Most desktop inkjet printers use their own proprietary printer language, and most additionally support HP's HPCL. In some cases, it is an advantage if the printer also supports PostScript, for example, if you want to print DTP documents. Most fine-art printers, however, do not consider this necessary – at least not for printing raster images, like photos. With inkjet printers, an integrated PostScript RIP will add about $ 150 US to the basic printer price. If you need PostScript printing only occasionally, you may use a software PostScript RIP in your PC. With Mac OS X, a software-based

PostScript RIP is part of the Mac distribution with GIMP Print, part of OS 10.4 installed. With Windows, you may use the free public domain version of GhostScript.

Exchangeable print heads

Some printers – usually consumer inkjet printers (e.g. by HP), the print head is part of the ink cartridge. This makes cartridges somewhat more expensive, however, when the nozzles of a head are clogged beyond help, simply replace the cartridge and the problem is gone. With most Epson printers, you can't easily replace the print head but must send the printer out for repair. With some other HP printers (e.g. the Designjet 130), the ink cartridge and print head are separate, however, you may easily replace a print head with a new one. Being able to easily pull out the print head and clean it outside the printer using a hot damp tissue or even some alcohol definitely is an advantage when the print head is clogged or has nearly reached the end of its life cycle.

Cutters

On large-scale printers, a paper-roll feeder is standard. For these printers, it is an advantage when the printer has an automatic paper cutter. Many of the default cutters on large-format printers, however, are not suited for heavy paper. For heavy paper you may have to replace them with cutters available as optional accessories.

Densiometers

Some printers have an integrated densiometer allowing measurement of the density of color laid down on paper. This allows the firmware of the printer to recognize clogged nozzles, and may also help auto-calibrate the printer. HP uses this technique in some of its inkjet printers (e.g. HP Designjet 30/130). Be aware that this is no substitute for a profiling device.

Table 1.3: Features a new fine art printer should have

Feature:	Recommended:	Note:
Printable area	≥ A3+(13" wide)	
Printer resolution	≥ 2400 × 1200 dpi	
Print engine speed	≤ 8 minutes for an 8" x 10" print of an image at 1,400 dpi	Not too important when not printing commercially
Borderless printing	Optional	Not needed for fine art prints
Number of inks	≥ 6 inks	Preferable separate cartridges for every ink
Ink cartridge size	As large as possible	≥ 10 ml for an A4/A3 printer
Droplet size	1–5 picoliter	
Ink characteristic	High lightfastness when used with matching paper	Lightfastness ≥ 20 years for color prints, ≥ 30 years for B&W prints (using WIR specs)
ICC profiles	Good generic profiles should be provided by the manufacturer	Should provide setting-/ quality -dependent) profiles
B&W printing	3 shades of black ink	Special printer driver mode for B&W printing
Maximum paper thickness	≥ 0.4 mm	More is better
Roll paper feeder	Optional	Useful for panoramas and unattended printing of many prints
Paper cutter	Optional	Only needed when using roll paper
PostScript RIP	Optional	May be done by an external Software-RIP
Printer interface	USB 2.0	Firewire optional. LAN interface very useful for large-scale printers and when printing from several systems

Chapter 2

Inks, Papers and Print Permanence

Camera: Nikon D1X

2.1 Print permanence

One important aspect of fine art printing is permanence of the print. You don't want a print to lose and/or change color and appearance in a short period of time. Whether you sell or give your prints away, print permanence is determined by three major factors:

- Stability and permanence of the paper
- Permanence of the ink (its colorants). Additionally, ink and paper must match and work smoothly together.
- Environmental factors, such as light (especially UV), temperature, humidity and gasses (especially ozone)

The permanence of a digital image is limited only by the permanence of the digital storage media, whether hard disk, CD/DVD or tape. You may extend this range by making a copy of the data on newer media (at a later time). You must still be cautious to ensure that your media may still be read by your computer – hardware, as well as, operating system – and that your printing application still supports the data format used. In most cases, this will (hopefully) be years in the future. *Permanence,* in this case, means that you can read the data without (unrecoverable) errors and can open the data for printing or modification.

When you make a print of an image, its permanence may range from 4 weeks to many years, very broad indeed. *Permanence* means that the print will maintain its visual impact without noticeable deterioration – that colors do not fade and the paper does not yellow. This definition of *print permanence* has two soft factors:

- What is a 'noticeable image deterioration'?
- What are the conditions in which the print is kept?

Until late 2005, there was no ANSI or ISO standard for print permanence (print longevity). Each supplier of printers – also usually supplying ink, as well as, paper – plus any supplier of paper and ink may state a permanence for his materials without precisely defining the circumstances leading to that data. However, in the community of fine art printers, there is a 'quasi' standard currently defined by the *Wilhelm Imaging Research Institute* (WIR, [60]). This institute, founded by Henry Wilhelm and his wife Carol Brower Wilhelm, is one of the most highly recognized and established institutes for the testing of

print permanence and lightfastness. Most serious manufacturers of components for fine art printing (e. g. HP, Epson and Canon) and with professional printing in other areas, use this institute to obtain permanence tests. The institute is highly independent-minded and, in this spirit, publishes its tests. You may find a large number of results for various papers and inks (and paper/ink-combinations) at their web site.

They use a well-defined test procedure for their permanence tests of prints, and try to improve their tests periodically, taking into account additional factors for fading (e. g. air pollutants).

Naturally, there are a number of other institutes that do the same and may be taken seriously (e. g. IPI – the *Rochester Imaging Permanence Institute* [48]), still Wilhem Imaging Research defines "the reference."

'Display Permanence Ratings' are predictions

When we talk about the *display permanence ratings* (DPR for short) of fine art prints, we look for and talk of a *permanence* of at least 25 years – preferable longer. By using adequate fine art papers and inks you may achieve a permanence of 60–100 years and longer. For Black & White prints, this figure may well rise to more than 160 years – color ink colorants are more prone to fading than those used for black.

As fine art printing (at least using ink printers) is not old, and as no manufacturer can wait long years to issue a permanence figure, all numbers provided are based on accelerated tests and predictions. Prints are exposed to much brighter light (about 2,0 00 Lux) and at higher temperatures than used in a common exhibition or office environment, and these results are extrapolated, on the basis of many and long experiences – but, nevertheless, are predictions that may prove not be precisely exact and true.

The Wilhelm research institute, for example, assumes an average light level of 450 lux as an exhibition condition for a print – 12 hours a day (Most serious testers at other companies use 450 or 500 lux at 12 or 10 hours/day, respectively). They also assume that the print is displayed behind (normal) glass and displayed at 24° C (75 ° F) and 60% RH (*relative humidity*). See figure 2-1 on page 2-4 for some examples of WIR ratings.

WIR Display Permanence Ratings for Current Products in the 4x6-inch Photo Printer Category

Type of 4x6-inch Dye-Sub Photo Printer, Inkjet Printer/Inkjet Paper, And Digital Silver-Halide Color Paper/Digital Minilab Photo Printer[1]	WIR v3.0 Endpoints at Both 1.0 and 0.6 Densities With Cool White Fluorescent Illumination and Years of Display Based on 450 lux/12 hrs/day With Prints Framed Under Glass[2]
1. Epson PictureMate Personal Photo Lab (and new PictureMate Deluxe Viewer Edition) – Printed with Epson PictureMate Inks and Photo Paper (pigment-based inkjet prints)	**104 years**
2. HP Photosmart 325, 335, 375, 385, 422, and 475 Compact Photo Printers – Printed with HP Vivera Inks (HP 95, 97, 343, or 344 Tri-color cartridges) (dye-based inkjet prints) With HP Premium Plus and HP Premium Photo Papers, High Gloss, Glossy, or Soft Gloss	**82 years**[3]
3. Canon Selphy DS700 Compact Photo Printer (dye-based inkjet prints) – Printed with Canon BCI-16 tricolor ink cartridge and Canon Photo Paper Pro PR-101	**41 years**
4. Fujicolor Crystal Archive Type One Paper (silver-halide color prints) – Printed with Fuji Frontier 370 digital minilab and Fuji washless chemicals	**40 years**
5. Kodak EasyShare Printer Dock, Plus, Series 3, and 6000 Printers (dye-sub prints)	**26 years**
6. Dell Photo Printer 540 (dye-sub prints)	**26 years**
7. Agfacolor Sensatis and Agfacolor Splendix Papers (silver-halide color prints) – Printed with Agfa d-lab.2plus/Select digital minilab and Agfa washless chemicals	**22 years**[4]
8. Kodak Edge Generations and Royal Generations Papers (silver-halide color prints) – Printed with Noritsu QSS-3011SM digital minilab and Kodak washless chemicals	**19 years**[5]
9. HP Photosmart 145 and 245 Compact Photo Printers (dye-based inkjet prints) – Printed using HP No. 57 Tri-color cartridge with HP Premium Plus and HP Premium Photo Papers, High Gloss, Glossy, or Soft Gloss	**18 years**
– Printed with HP No. 57 Tri-color cartridge and Kodak Ultima Picture Paper, High Gloss (Ultima ColorLast "Lasts Over 100 Years" version)	**11 years**[6]
10. Konica Minolta QA Paper Impresa and Centuria For Digital (silver-halide color prints) – Printed with Konica Minolta R2 Super 1000 digital minilab and Konica washless chemicals	**17 years**[7]
11. Lexmark SnapShot P315 Photo Jetprinter (dye-based inkjet prints) – Printed with Lexmark 33 or 35 color ink cartridges and Lexmark Premium Photo Paper	**16 years**
12. Olympus P-10 Digital Photo Printer (dye-sub prints)	**8 years**
13. Canon CP-200, CP-220, CP-330, CP400, and CP500 Printers (dye-sub prints)	**7 years**
14. Sony DPP-FP30 PictureStation Photo Printer (dye-sub prints)	**6 years**
15. Sony DPP-EX5, DPP-EX7, and DPP-EX50 Printers (dye-sub prints)	**4 years**

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. . . . continues next page

Figure 2-1: Some permanence ratings by WIR (Courtesy of Wilhelm Research Inc, [60]). See [62] for the complete and original document.

But, you cannot rely on these conditions, as not all print material suppliers use the testing conditions used by **Wilhelm Imaging** Research (or even close to it). Read claims carefully. Kodak, for one, seems to use two different types of tests: one for consumer materials, yet another for professional materials – but until now, you will probably not find a note informing you which papers Kodak rates as *consumer* and which as *professional*. The numbers resulting from these two tests differ quite a lot (up to a factor of 5)! The reason for this is that they use 120 lux/12 hours per day testing consumer material versus 450 lux testing professional material and assume a UV filter will be used when displaying the print. The reality is that most tests use a standard glass filter (which absorbs much less ultra violet light).

Some of the permanence ratings Canon provides are for *dark room* or *album storage*. The decline of print quality in dark room storage is drastically slower that in a lighted office environment, and we have seen fading in prints done with Canon dye-based inks and papers, specified to have a print permanence of about 100 years, in less than 4 weeks when presented in a well-lit office environment. Only the fine print describes a given permanence as *dark room storage* permanence. What good is long dark room permanence if you want to hang your prints in an office or studio environment?

There are several environmental factors influencing the permanence of prints, and not all are yet fully understood and evaluated. Some of the well-known factors are

- Ink
- Paper
- Paper to ink match
- Light – the UV-spectrum causing the strongest fading effect
- Temperature (the higher the more damaging)
- Relative humidity (the higher the more damaging)
- Gasses – ozone is now considered one of the most degrading factors in an 'office environment', but sulphur gases are destructive, as well.

Now, let's have a look at each of these factors: For inks and papers see section 2.2 and section 2.3 respectively.

Light as a factor of print permanence

Light is one of the dominating factors in the permanence of prints – provided you use reliable, stable inks and paper to match. The more light your prints receive, the faster their colors (colorants) degenerate. But not only the quantity of light determines degradation, but also the spectrum (wavelength) of that light striking the print – shorter wavelengths have greater effect than longer ones. Especially, the ultra violet spectrum (UV) light has a higher energy and higher destructive effect (see figure 2-1). Direct unfiltered sun has a very high degree of UV in its light spectrum. For this reason, fine art prints should not be exposed to direct sun light.

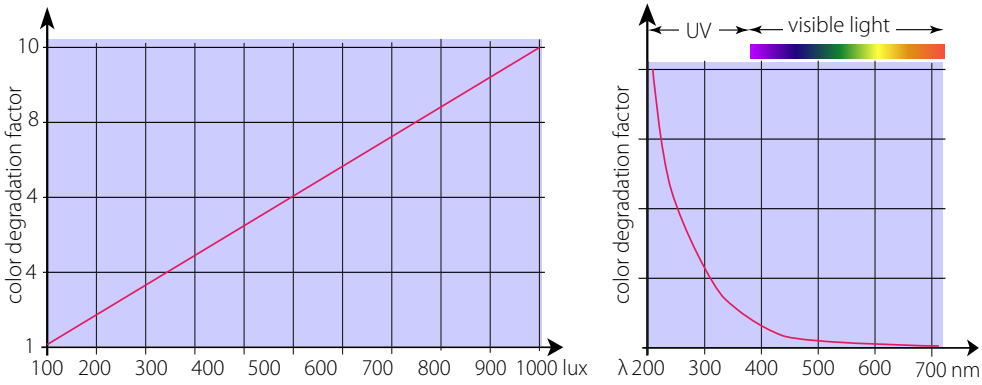


Figure 2-2: Influence of the light on light fading
(Note: the right diagram is a very rough approximation, and the scale is logarithmic)

Not all ink colors fade at the same rate. So, (with most pigmented inks) yellow fades less and slower than other colors (e. g. cyan). This may lead to stronger color shifts than if all colors faded at the same rate. Usually, there is a shift from red and green to yellow and from neutral (built with CMYK) to reddish.

Temperature influencing 'dark fading'

When storing (archiving) prints for an extended time, temperature is a critical factor. Its influence is termed *thermal degradation* or *dark fade* as this fading also occurs when prints are stored in the dark. From our chemistry classes, we remember, that higher temperature accelerates chemical processes and image decay is mainly a chemical process. Figure 2-3 illustrates that temperature is a dominant factor in image degradation when stored in the dark (Temperature also influences images in the light, but the light factor is dominant).

Please note, that while the X-axis (temperature) is linear, the Y-axis (Longevity factor) is logarithmic!

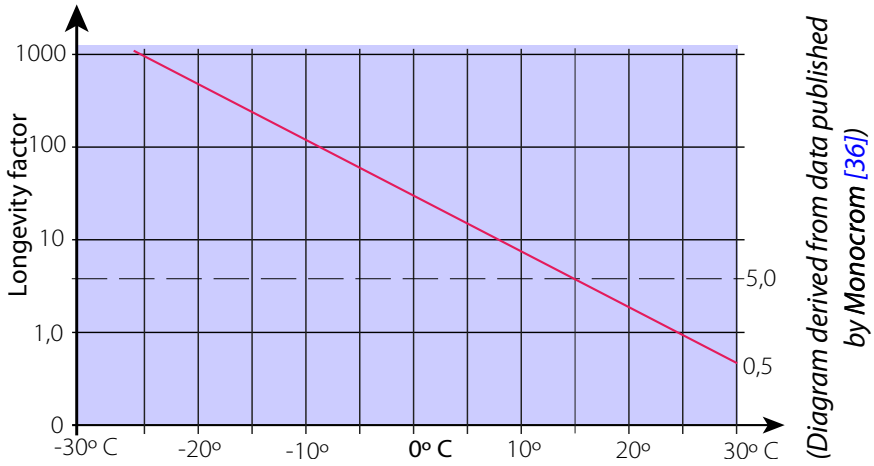


Figure 2-3: Permanence factor in relation to temperature.

Humidity

Relative humidity will influence the longevity of a print – but, not as strongly as temperature. The higher the relative humidity, the shorter longevity of a print will be. The graph of figure 2-4 was derived from data published by Monchrom [36].

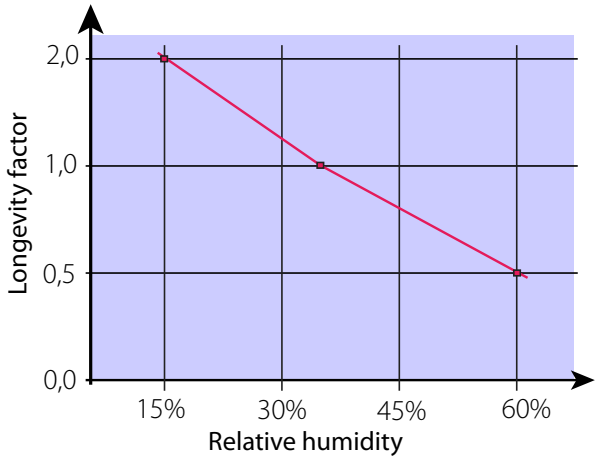


Figure 2-4: Permanence factor in relation to air humidity (diagram derived from data published by Monochrom [36])

Even if relative air humidity is not dominant, consider, that humidity above a certain level – around 80 % – may lead to fungal decay which, in turn, may spoil your prints very quickly and seriously. Consider that humidity is influenced by temperature. When the temperature in a room drops, relative humidity rises.

Gases and their influence on print longevity

There are several gases in the air that influence print permanence. Currently, ozone is the one that is assumed to have the strongest effect on permanence. Ozone, produced by unfiltered sun, as well as, by some machines, accelerates oxidation and, as such, the decay of colors. Ozone is known to act as a bleaching agent.

One of the advantages of framing with glass, acrylic (e.g. plexiglas) or other coating is the effect that air flow – continuously supplied fresh ozone – is reduced or even stopped altogether. The more UV light (ultra violet light) you have in your environment, the more ozone you will probably have, as UV light stimulates the production of ozone. Also some electric engines, like laser printers, photo copying machines, air-conditioners and refrigerators, produce ozone.

With the decrease of the ozone zone in the sky – e.g. very advanced in some geographic areas like Australia – the UV level and with this, the ozone level on the earth surface rises.

There are more gases in the air suspected of having a negative effect on the longevity of prints. For example, NO_2 (nitrogen dioxide) and SO_2 (sulfur dioxide) are suspected of yellowing paper. Their influence, however, is not yet well understood, and their intensity, in most cases, is lower than that of ozone and (concerning current knowledge), their effect is smaller.

Additives to paper can also influence the light stability of a print. For example, optical brighteners, mainly used to make paper appear whiter, can have a negative effect on photo-fading, as their lifespan is rather short (a few years). (They also may have a negative effect when doing ICC profiling. For this reason, we try to avoid papers with a high degree of optical brighteners.)

How to improve the permanence of your prints

Actually the recipe for maintaining your prints and their colorants as long as possible is very simple: Keep them dark, cool and dry. While this may be adequate advice when storing prints in an album – even there, keeping them cool can be a problem, dryness, as well, in some areas of our world. None of these is practical when prints are to be displayed.

There are several ways to improve print permanence (for more on framing, post-coating and lamination see chapter 9.3):

- **Framing using a glass or acrylic cover**.
  A covering reduces gas flow and has a filtering effect on UV light. Additionally, it helps protect a print from sporadic humidity, dust and dirt stemming from flys or other insects.

  Standard glass or standard acrylic somewhat reduces the UV spectrum of light hitting an image – partly by reflecting some of the light and partly by absorbing a portion of the UV spectrum of that light. Even normal window glass reduces UV light by up to 90 %. Using special glass, as some museums do, you can achieve a reduction of up to 99 % or more. There are also foils on the market – though quite expensive – that absorb about 99% of the UV light.

- **Spraying/coating**
  Standard glass adds to reflections and is not always suitable for some types of presentations. To protect a print from UV light, ozone and soiling, you may coat a print using either a spray or a brush to apply protective material. The most difficult thing is finding the appropriate ingredients to do coating. Though there are many solutions available, only a few have a proven record, still fewer a certificate from one of the well known institutes (like WIR) stating a factor of improvement. Additionally, ink, paper and ingredient all must match each other.

- **Reducing UV light**
  Since the UV spectrum of light has the most damaging effect on print permanence, it helps if you can reduce the UV spectrum in your office. This may be accomplished by using appropriate lighting (e.g. unfiltered fluorescent light has a higher UV spectrum than tungsten light) or by either covering the light source with special glass or foil to absorb much of its UV light or by covering your print with UV absorbing glass or foil. This glass can absorb about 99 % of UV light.

- **Laminating**
  The purpose of lamination is similar to coating – protecting a print from UV light, ozone and grease. An advantage of lamination over coating is that – at least with some lamination techniques – both sides of the print are protected in the process. This may give your print greater protection and more robustness.

2.2 Inks

Ink and matching paper are, in fact, the basis for prints with high print quality and high longevity. Inkjet printers have been around for about 15 years. Until manufacturers came up with pigmented inks, you might produce good looking photo prints with your inkjet printer, but the image didn't usually last long. Some even showed noticeable degradation within a few weeks – or even within a few days when exposed to sunlight. One of the first companies to address this with reasonably priced inkjet printers and an acceptable image lightfastness, was Epson with their first generation UltraChrome® ink in 2001. In 2005, Epson and UltraChrome K3 introduced its third generation of this pigment-based type of ink.

Returning to the basics of inks, desktop inkjet printers, use basically two types of inks:

- Dye-based
- Pigment-based

You may even see some hybrid inks, where dye-based ink is used for colors to achieve a large gamut, while pigment-based ink is used to create black, a dark, dense, saturated black and better longevity (e. g. Canon does this with some printers). Some publications use the term *pigmented inks* referring to hybrid inks. In this book, we use the term for true inks with solid pigment.

Each of these 2 types have their specific advantages and drawbacks. For both kinds, we hope to give a general overview. Keep in mind, however, that though both kind of inks have their typical weaknesses, much progress has been made during the last few years overcoming some specific shortcomings. For example, HP achieved a very respectable longevity of about 70–200 years with its dye-based Viveria® inks (dye-based inks tend to have general problems concerning lightfastness), while Epson managed to achieve a quite rich color gamut with its third generation of pigment-based UltraBrite® and UltraChrome® inks. Pigment-based inks tend to provide a smaller gamut. In reaality, with desktop printers, you normally have no choice between dye-based and pigment-based inks for a particular printer – they are either one or the other. With some large-format printers, different kinds of inks may be used on the same printer.

Dye-based inks

With dye-based inks, the colorants are water soluble and dissolved in the ink liquid. Thus, when hitting the paper, they sink into the paper or its coating. But a small portion remains on the surface. This makes dye-based inks well suited for glossy paper, but are equally well suited for matte papers. When the liquid dries, the colorants attach to the fibers of the paper or molecules of the coating. To prevent bleeding too much and mixing with neighboring color points, in general, a coated paper may be used (see section 2-2). To give the print maximum vividness, its coating should be transparent. As the ink penetrates the paper surface or coating, dye based inks deliver better scratch resistance than pigmented inks.

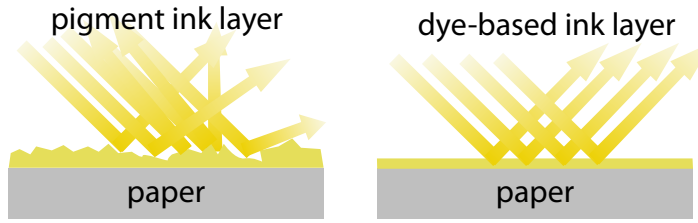


Figure 2-5: The dye molecules are much smaller than pigments. Pigments give a more disperse light reflection.

Compared to the colorants in pigmented ink, the molecules in dye ink are much finer – up to a factor of 1,000! As dye-based inks contain a higher percentage of liquid (mostly water), they need a bit longer to dry. Also, such prints are more prone to smudging when coming in contact with moisture or when touched by a moist finger. A microporous coating (or other special sizing) can compensate for both of these effects.

The disadvantage of these tiny dye molecules is that they have a larger surface open to attack by light and air contamination, like ozone and SO_2, this situation leading to faster fading. To reduce this effect, HP and other printer-makers recommend using swellable papers (see section 2-3) for optimal print permanence.

Most desktop inkjet printers and many large-format printers today use dye-based inks. Almost all HPs and Canons printer use them.

Dye-based inks are cheaper to produce than pigment ink and are less prone to print-head clogging. Even if the print-head is clogged, it cleans easier (with a moist Q-Tip or a damp tissue) than the heads of

pigmented ink machines. Even if the colorants in the ink should settle down in the ink cartridge after some time, it will dilute when the ink cartridge is shaken.

Dye-based inks tend to provide a richer color gamut, more vivid colors and a darker black than pigmented inks (yet newer formulations of pigment inks attempt to compensate for this fact).

Pigmented inks

In pigmented inks, the color stems from pigments – comparatively large colored material. A *pigment* consists of a tightly coupled conglomerate of colored molecules. A single pigment is about 1,000th the size of a molecule of dye used in dye-based inks. This leads to a series of advantages and disadvantages. One advantage lay in the size of the pigment. The pigment has a relatively small surface and, thus, more resistance to light, water/moisture and aggressive air pollutants. It gives pigment inks a high fading fastness against light, moisture, gases and temperature.

The downside of pigments is their somewhat reduced color intensity (at least, compared to dyes) and that they poorly dissolve in the solvent of the ink. Thus, there is a tendency to settle at the bottom of the ink cartridge, similar to sand in a river. You can stir them up, but, after some time, they sink down once more. The cartridges of pigmented ink should consequently be thoroughly shaken (while closed and packed) before inserting a new ink cartridge into the printer. The ink of such an ink cartridge in a printer should be used up inside approximately six months.

Also, pigment-based inks tend to show a stronger *bronzing* effect than dye-based inks. Here, dark or black areas show a slight color of bronze under some lighting. Similar pigment-based inks show a stronger tendency toward metamerism, where two colors look identical under one lighting situation, but look different viewed in a different lighting situation.

When used in an inkjet printer, most of the ink/pigment will settle on the surface of the paper and not penetrate the paper (or its coating) to the same degree as dye-based ink does. As the pigment sits mainly on the surface of the paper, the print is more prone to abrasion than are dye-based inks. On the other hand, pigment ink dries faster than dye-based ink since pigment ink uses less solvent. With pigment ink, your choice of paper is somewhat expanded, as

you may use coated, as well as, uncoated paper (uncoated paper is prone to ink bleeding and a large dot gain), but you may use swellable, as well as, porous coatings.

Because pigments mainly reside on a paper's surface, the gloss of a color very much depends on the quantity of ink/pigment used in the various areas of the print, resulting potentially in an uneven gloss. Additionally pigments give a more dispersed reflection (see figure 2-5). For this reason, pigment ink is better suited for matte or semi-matte surfaces than to glossy paper. You might compensate for this by post-applying an additional gloss coating if gloss is desired (Epson offers this in its R800/R1800 printers by using a separate gloss optimizer cartridge).

Another disadvantage of pigmented inks is that they are more prone to print-head clogging.

The greatest advantage of pigmented inks is the considerable longevity of prints when using them, based on their better light stability, gas resistance and temperature fastness. Additionally, there is less tendency of prints to smudge when touched with moist fingers or a high moisture content. All this makes pigmented inks very attractive for long-lasting and stable fine art prints. As Epson demonstrates with its new generations of pigmented inks (DuraBrite™ and UltraChrome K3™), using the correct formulation, you may overcome restrictions concerning reduced color gamut, and you may achieve a high maximum density (Dmax) in a print.

We assume that both HP and Canon must migrate to pigmented inks if they want to continue to succeed in the fine art and high quality photo printing market.

The quality of inks of both kinds – dye-based and pigment-based – has considerably improved over the past few years. The lightfastness of dye-based inks was improved considerably and the color gamut of pigment inks has likewise increased. The tendency towards bronzing and metamerism with pigment-based ink has been considerably reduced – especially by Epson. The total color gamut achievable with inkjets is ultimately improved by better inks and the usage of an increased number of primary colors.

2.3 Papers

Paper is an ancient, well understood material. Invented by the Chinese and in mass-production for roughly 600 years in the western world, we inherit a long and rich tradition of paper making. There are several paper makers today whose companies date back several centuries. Hahnemühle, for example, is one of the best known German paper makers for fine art, dating back to 1584.

Most of the time, we are unaware of the stability or longevity of paper, but have our eyes on its color and, the feel of the surface and the color gamut we can achieve printing on it. For fine art printing, however, we must consider two other things:

- Longevity and lightfastness of the paper itself
  (it should neither begin to disintegrate nor yellow)
- Suitability of the paper for the ink used
  (the paper must absorb ink without the ink bleeding excessively, dry quickly, not warp and – with dye-based inks – must protect the ink from ozone and other pollutants in the air)

The longevity of the paper is largely determined by the ingredients in the paper and how is its stored. There are two longevity aspects with paper:

- The stability and constitution of the paper. Today, if you use chloride-free, acid-free papers, this is not an issue. The paper will remain stable for hundreds of years – if stored under the correct conditions.
- The paper should not noticeably change color over the period of time considered – it should not yellow. One precondition for this is that it be lignin-free and not contain an overabundance of optical brighteners.

For fine art printing, in most cases, special fine art papers should be considered. Fine art paper for inkjet printing is almost always specially coated for printing.

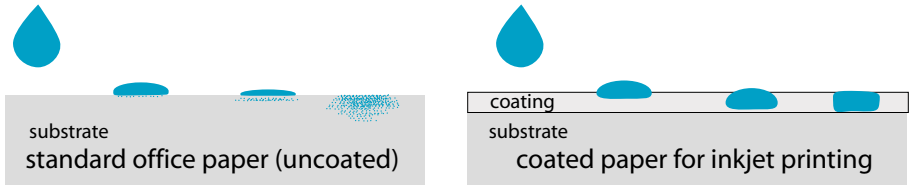


Figure 2-6: The coating prevents the ink from bleeding.

Thus, paper consists of a base material (*substrate*) and a coating (and/or *sizing*) that ensures, that the ink is properly absorbed by the paper and drys quickly. Additionally, the coating must prevent ink from bleeding. This permits higher resolution printing and finer color gradients.

Paper characteristics

There are many characteristics of a paper. Here are some of them important to our purpose:

- the raw material the paper is made from
- coating (influencing absorbency) – single- or double-sided
- color (whiteness and brightness) and opacity
- base weight and paper thickness
- surface texture (finish)
- size

The technical part of a technical data sheet might look like the following one, extracted from specifications of Hahnemuehle Photo Rag:

Physical Characteristics (Hahnemuehle Photo Rag™, 308 g/m²)

	Unity	Valuation	Test Norm / Notes
Test Conditions		23° C / 50% R. H.	CSS19
Weight total	g/m²	188	ISO536
Thickness	mm	0,30	EN 20534
Whiteness	%	97,5	ISO 11475 (W_{cie}/ D65,2°)
Opacity	%	92,5	DIN 53146
Media Color		white	not bleached
pH-Value total		7,9	DIN 53124
Water resistance		very high	
Cobb		70,0	EN 20535
Ink limit	%	245	
Special features	optical brighteners		

All indicated data to be understood as typical average values.

Paper ingredients

The raw material composition of a paper largely determines its quality – its behavior for printing, display and storage. With fine papers for inkjet printing, we encounter (at least) two layers: the paper base and a coating onto this base. The top layer is also called the *ink reception layer* or *inkjet receptive layer*. Both its layers and its raw materials are important in giving a paper its characteristics. Here, we specifically want to focus on papers suited for fine art prints. For them, there are two basic kinds of raw materials: cotton (rag) fibers and cellulose fibers – and any combination of the two. Thus you may have rag paper, half-rag paper, wood-free and wood-containing paper. Today, only few real rags are used, mostly raw cotton – even if a paper's name implies otherwise.

There are many other ingredients in the paper to give it the desired color, surface feel, pH-value, absorbance and finish, yet cotton/rag or cellulose from wood remain the two basic ingredients.

Rag paper may contain up to 100 % cotton or linen fiber and is the most expensive paper. But one may mix cotton/rag with cellulose in almost any combination to reduce cost. From a quality point of view, cotton/linen-based paper is the better paper, but good cellulose-based paper, nowadays, can achieve about the same longevity as rag/cotton paper.

Cellulose is mainly produced from wood, but there are other plants, like hemp, used for cellulose production, as well. Wood pulp contains a lot of *lignin*. Lignin causes low-quality papers to yellow and works as a kind of glue in the cellulose cell. For good-quality papers, lignin – sometimes also called *lignen* – must be removed during the pulping process.

To differentiate between cotton paper and mainly cellulose-based paper, sometimes the term *alpha cellulose* paper is used for the latter. Also the term *sulphite* or *sulphite paper* is used for this paper as the wood pulp is cooked in sodium sulphite or in calcium bisulphate.

Whatever the raw material may be, it is important that the paper is acid-free, meaning it has a pH-value of 7.0 or greater. While for some time, 7.0–8.5 pH was considered optimal for archival papers, new findings lead to a range of 7.0–10.0 pH. A pH-value of 7.5–9.0 seems ideal and gives some buffer for acid picked up from acidic air pollutants. These papers are also referred to as *buffered* papers. This buffering is often achieved by addition of calcium carbonate.

Whiteness and brightness

The whiter a paper is, the higher contrast you may achieve in your print and the richer the color gamut may be. For this reason, there is a tendency with photographers toward bright white papers. As the base material for paper is not bright white, paper manufacturers must use some tricks to achieve proper whiteness. This is especially true, when the coating is transparent. If you look at the numerous variations of fine art papers, you will find a very wide range of shades of white, from a bluish bright white to a 'natural' white (meaning a tint of yellow or beige) to ivory or creamy white.

There are several techniques to improve whiteness and brightness of paper – e.g. bleaching. Even white colorants are added to the paper base material. Additionally, optical brighteners may be added – partly to compensate for possible color variations in different paper batches. You will see optical brighteners even in well known fine art papers like the Photo Rag of Hahnemuehle.

Technically, the brightness is measured in percent of light reflection and ranges from 0 (or 1) to 100 %. While multipurpose bond paper (used for copying machines) has a brightness of in the 80s, most fine art paper's brightness lay in the range of 90–98.5 %.

As our eyes/brains very much adapt the white we perceive, most papers look very white when viewed in isolation. The true color becomes visible when compared to other white surfaces – e.g. that of a matte or white frame.

When you choose a paper, you should take into account the subject you want reproduced in your print. For most portraits, for example, no really bright white is advisable – sometime may even be disturbing. The same is true for most landscape subjects. If you can do with a paper having lower whiteness, you may be able to use a paper free of optical brighteners.

Optical brighteners

Optical brighteners (also called *optical brightening additives* – OBAs for short) in paper are used to remove any yellow appearance of the raw materials. Additionally, optical brighteners do increase the brightness of a paper thus increasing the maximum contrast that can be achieved in a print, and enlarging the color gamut than can be achieved, as well. They also increase the reflectivity of a (white)

paper. Most optical brighteners are fluorescent brighteners. They absorb light in the UV range and re-emit white light in the visible range (tending toward blue).

There are some disadvantages to optical brighteners. They begin by confusing a spectrophotometer when measuring colors for ICC profiling. This may lead to creating erroneous ICC profiles. A more important factor may be that brighteners deteriorate faster than (good) ink colors. This may lead to a gradual color shift in the print. Usually a paper manufacturer will provide a note when an optical brightener is used for a digital fine art paper (but the amount may vary somewhat from paper batch to paper batch). There are different quality brighteners – better ones deteriorate more slowly. Papers using fluorescent-based optical brighteners can lose some of their brightness and whiteness when the light source has little or no UV light or when UV filters are used.

For these reasons, if long-term image permanence is an important issue, fluorescent brighteners should be avoided or minimized.

You may test a paper for optical brighteners by viewing the paper in the dark using a UV light source. If brighteners are present, the OBAs will glow under UV.

Paper weight and paper thickness

The weight of a paper is given in either gsm (***g****rams per* ***s****quare* ***m****eter*) or in lbs. (pounds per 500 sheets (ream) of a specific size). We consider gsm better for comparison as it is independent of the paper size. For fine art printing, a heavy paper usually is preferred as it gives your print rigidity and a more substantial feeling. While a standard office copy paper measures about 80–120 gsm, a traditional low-cost photo paper is about 120–150 gsm. Personally, we prefer papers of 230 gsm or heavier.

A second measurement to look for is actual paper thickness – also called *caliper* – as not all paper has the same weight per square meter. This measurement is either given in millimeters (mm) or in *mils* (a *mil* is a thousands of an inch and is abbreviated by 'mils' – 1 mils = 0.0254 mm; 1 mm ≈ 39.4 mil). Photo paper is usually 7–10 mils (ca. 0.18–0.25 mm), typical fine art papers 10–35 mils (0.25–0.90 mm). Using thick papers, you may have to manually assist the printer in feeding the paper, or perhaps using a straight paper path and set special options in the printer driver (e.g. see page 5-14). Using light

papers, on the other hand, you may have to reduce the amount of ink to prevent warping (e.g. see page 5-14).

Paper coating

For inkjet printing, paper may be *uncoated* (like 'bond paper' used for laser printers and photo copying machines) or may be *coated*. Traditionally, many fine-art papers used for painting or drawing are uncoated, many of them with a very fine surface. Though you may use these papers also for inkjet printing, as mentioned before, for true fine art prints you should use coated paper. The coating may also affect the surface finish of the paper – e.g to be more matte, satin or glossy. There are several different types of coatings. For inkjet printing these are the coatings used most often:

- microporous
- swellable
- resin coated (RC)

Microporous coating ▸ Here, the coating consists of a fine layer of ceramic (inorganic, inert particles) material ground to fine powder. The ink sinks into the cavities of this layer and is thus absorbed quickly with minimum spread. Inks printed on this kind of paper dries very fast. This coating provides good water-resistance. The disadvantage of this paper is in the open areas of the coating allowing dye-based colorants of the ink to come in contact with air-contaminants (see figure 2-7) and thus these gases accelerate deterioration processes of the ink. For this reason, microporous papers are not the best choice for dye-based inks when print longevity is required.

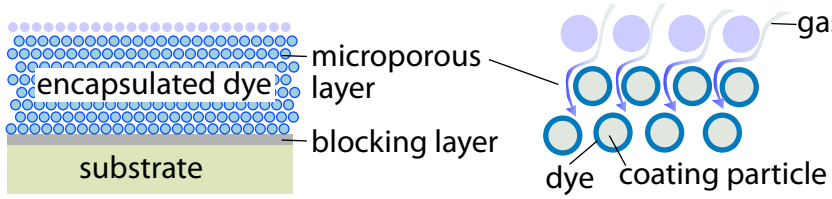


Figure 2-7: Structure of a microporous paper (Source: HP, [86])

With pigmented inks, usually use microporous papers. They dry very quickly and allow sharp images. Pigmented inks do not sink in like dye-based ones leaving their pigments on the surface.

Swellable papers ▸ As their name implies, the coating is made of material (polymers) which swell in the presence of moisture – when the inks hits the paper. The coating absorbs the ink and allows the colorants to penetrate the top layer of the coating. The encapsulating layer below encloses the colorants (dyes) leaving only minor parts of the dye on top of the paper (where it is exposed to light and gases). With swellable papers, you usually have a four-layer paper:

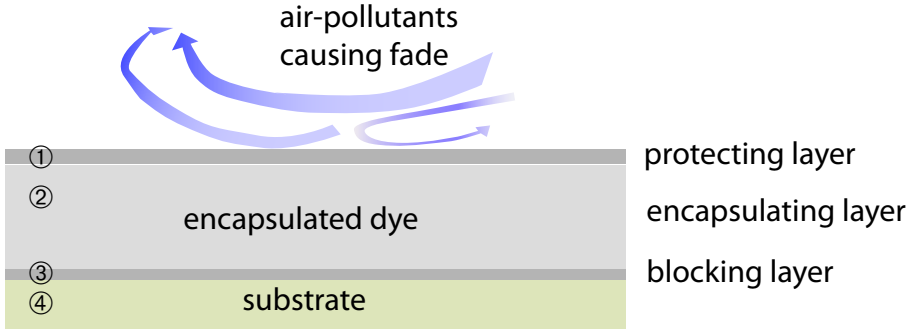


Figure 2-8: Layers of a swellable inkjet paper (Source: HP, [86])

These papers, primarily intended for dye-based inks, can give a very fine and crisp print quality, but are sensitive to high humidity and water contact. You may find swellable papers from Epson , **Fujifilm** (e.g. Premium Plus), HP (e.g. 'HP Premium Plus Photo Paper'), **Ilford,** Kodak and others. Most of these papers are either glossy or luster/satin.

Swellable papers take a bit longer to dry – the swell caused by the inks has to revert. Keep this in mind when handling prints on swellable paper. Wait even longer if you intend to frame a print, laminate or coat it. Colors also take a bit longer to stabilize and establish their final value. Keep this in mind if you do your own printer profiling.

When printing with the HP printers mentioned in Chapter 5.8 (using dye-based inks), we recommend using only swellable paper if print permanence is an issue.

Resin coated – RC papers ▸ This is not actually a real coating but a kind of paper well known in the photographic world for simple consumer prints from the wet darkroom (Classic, good quality, wet prints still use fiber-based paper). This kind of paper is now also used for digital inkjet printing. With RC papers, the base substrate is made of resin (plastic rather than paper) and usually sandwiched

between two thin polyethylene layers. To make it suitable for inkjet printing, either a swellable or a microporous coating is applied on top. This coating determines the printing behavior of the paper.

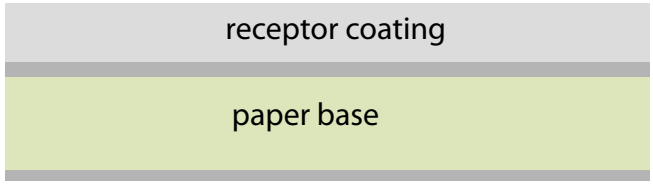


Figure 2-9: Layers of a RC paper

With some inkjet paper offered, a distinction is made between 'Fine Art Papers' and 'Photographic Papers', the latter meaning RC papers. Most RC papers provide a glossy or satin surface and are closer to the feeling of traditional consumer photo material. For many artists, this feeling is too similar to plastic and is unlike paper.

Do your own coating Finally, you may use uncoated paper and do your own precoating (before you print). Here, you must differentiate between *topcoats* (also called *overcoats*) which are intended to protect the finished print against UV light, abrasion and soiling and coating of the basic paper to make it suitable of inkjet printing. Here, we are describing the latter. There are several coatings for inkjet printing on the market, but we do not have personal experience with them. We have had positive reports from photographers using PixelTrust [82] and will try to gain further experience with this paper coating. Another coating we have encountered with several recommendations (but did not try ourself) is inkAID [83]. Both coatings may be applied with a brush or roller. You may also use low pressure sprayers. inkAID offers several different precoatings from White Matte to Clear Gloss.

Sizing The term *sizing* or *internal sizing* is used to describe the application of substances, such as hide glue or acrylic polymer ((((as a support to reduce the absorbency of the support and to keep the ink from coming in direct contact with the fibers that make up the support.)))) With different substances, absorbance of coatings is controlled. The term (*surface*) *sizing* is also used for the creation of special paper surfaces.

Paper surface – paper finish

As with silver-halide-based prints, you find papers with varying surface structure. For inkjet printing, the choice is even larger, and a paper's surface structure type is another way to classify papers. Starting with the most shiny surface there is:

- Glossy
- Semigloss, Luster, Satin
- Matte, Watercolor

While these names or attributes mainly describe surface glossiness, the surface may have an additional structure, most obvious when using canvas. While Glossy paper is usually very smooth, all less glossy papers may have varying degrees of surface structure.

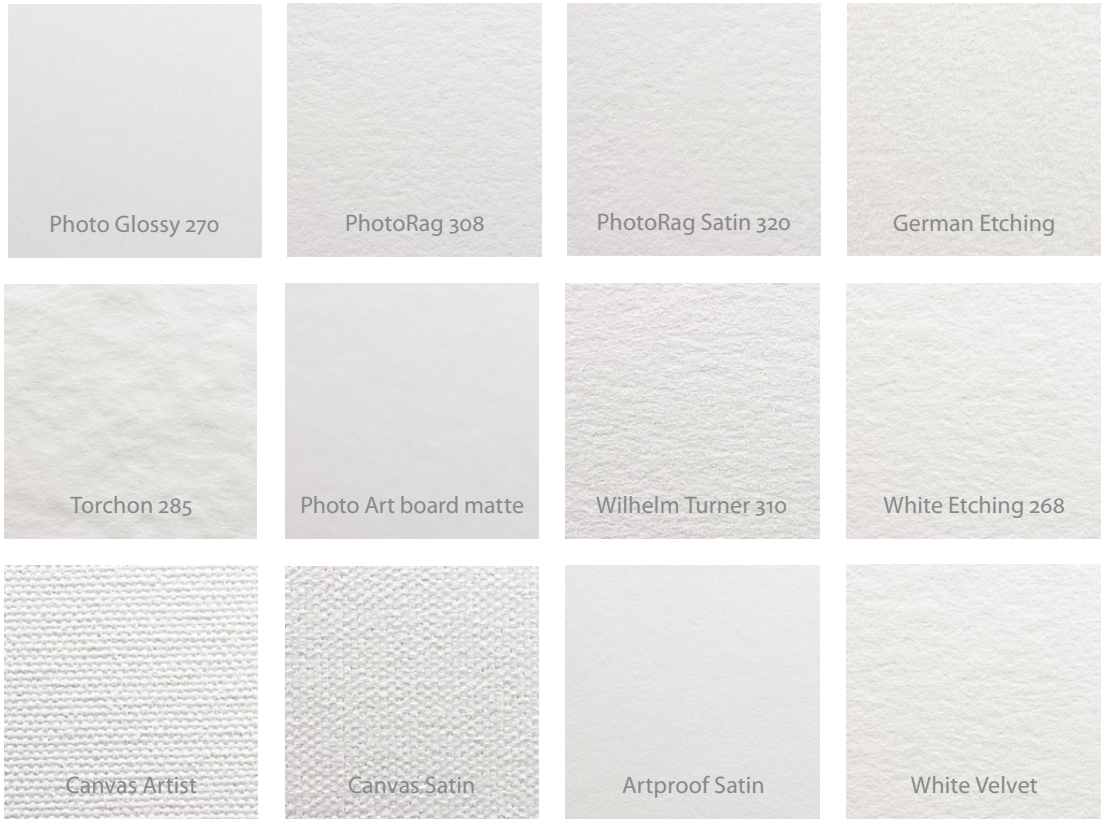


Figure 2-10: A small collection of a multitude of paper surfaces and colors. The images show some papers from Hahnemuehle (Courtesy of ***Hahnemühle Germany).***

The smoother the paper surface, the sharper a photo appears (provided you have sufficient contrast in the subject). For optimal bril-

liance, glossy and semigloss papers are best while matte and velvet papers provide some more abstraction – especially when used for black & white prints.

The surface not only has an influence on the visual appearance of the paper and the print, but may also have an effect on the suitability of the paper for certain inks and, thus, printers. As a tendency, glossy papers are not optimal for pigmented inks as pigments mainly reside on the surface and may interfere with the gloss of the surface. In order to offer a printer for a broad range of applications, the printer manufacturers of pigment-based inkjets tries to compensate for this effect – e.g. by including a gloss optimizer for glossy prints or by selecting an ink formulation that results in a glossy ink.

If you want to apply your own additional finish to a print – e.g. by doing a post-coating or embellishing, be sure that your coating material is not only compatible with your ink but also with your paper surface. Often, however, at least two versions of a post-coating material is available – one for glossy and one for matte surfaces. This, for example, is the case for the 'Eco Print Shield' product from PremierArt ([76]).

Paper size

Not all papers are available at all sizes. When we discuss fine art printing, usually, we talk about prints of at least 'letter' or A4. As most images require a minimal size for optimal impression, A3, A3+ and even larger are favorite sizes (see page 2-32 for more standard paper sizes). Another option is to use roll paper which you may either cut down to your preferred size (you will have to flatten the paper afterward) or may use with a roll feeder on your printer if you have one. Some papers may be cheaper when ordered in larger sizes and cut down to smaller ones.

Matching inkjet technology, subject paper and ink

In general, it is recommended that you use a paper that

- matches the type of printing method used (for this book it is inkjet printing)
- works smoothly together with the ink and print resolution that will be used
- suits the image subject
- suits your personal preferences

For a print with many fine details, such as a photo of a fashion model, a glossy bright white paper may give the best result – considering resolution, sharp detail, large color gamut. A print of a landscape with picturesque scenery may look better on a watercolor paper. Likewise a black & white print of a portrait may not want a bright white paper but may gain from a paper with a slightly off-white tint (often phrased 'natural white'). Here, Hahnemuehle 'German Etching' may be appropriate.

Keep in mind, that choosing paper is a very subjective decision (if the paper chosen provides proper longevity in combination with your ink and display conditions). There is no single right or wrong choice, and you may select different papers for different subjects in different print sizes. The larger the print, the thicker the paper – up to a certain size. For very large fine art prints, you may have to return to a thinner paper, as you will likely mount it to a separate backboard. When paper bonding is required, thinner papers are easier to handle.

Some more characteristics

There are other characteristics to influence your choice when selecting a paper. An important value is the pH-value of the paper. This value tells how acid or alkaline a paper is. 'Neutral' would be a pH-value of 7.0. When the paper is more acidic, it will destroy itself after a length of time. As paper may pick up acid components from the environment, other papers, a wooden frame or the air itself – most fine art papers have a native pH-value of 7.5–10. This provides a buffer when picking up acid. Fine art materials having a prescribed amount of added alkaline are called *buffered*.

Cobb number The *cobb-number,* mentioned in the table on page 2-15, gives an indication how much water can be absorbed by a paper in a certain amount of time. This number is rarely given by paper manufacturers and we have found no recommendation for *good* cobb values for fine art papers.

Ink limit The *ink limit* is an important factor in offset printing. Darker colors are built up by overlaying primary colors (in offset printing, usually C, M, Y and K), theoretically, up to 400% to be applied using four inks. This is, in many cases, more than a paper can take. (When too much ink is applied, the color will break or smear to the environment or the paper may warp). Thus the ink limit specifies how much ink may be overlaid at a particular point. The higher this value, the higher density may be achieved in dark or black areas of the print. Value beyond 230–240 are considered quite good using fine art papers.

With some RIPs, you may explicitly control the maximum amount of ink laid down.

Print maximum density (Dmax) According to Norman Koren [84] this is: "Dmax = -$\log_{10}$(minimum print reflectivity) and is a measure of the deepest black tone a printer/ink/paper combination can reproduce. This is an extremely important print quality factor. Prints with poor Dmax look pale and weak. Dmax = 1.7 is a good value for matte prints; 2.0 is good for glossy, semigloss and luster prints. There have been reports that the new Epson Ultrachrome K3 printers have Dmax as high as 2.3 with Premium Luster paper. If true, that would be outstanding."

You only rarely find this value in a data sheet of a paper-maker as this values also depends on the type of ink used and on some driver settings. These values become especially interesting when printing black & white. Dmax is measured using a densiometer but may also be measured using a good flatbed scanner and a spectrophotometer. Imatest, a tool provided by Norman Koren at [84], allows determination of the Dmax for printer-setting, for ink and a paper.

Opacity Opacity determines to what degree elements on the back of a sheet (or elements behind the paper surface) are visible. This is important when intending to print on both sides of the paper. This value may range from zero (complete transparency) to 100 (completely opaque). The thicker the paper and the more dense the

paper and coating, the higher the opacity value will be. For fine art papers, opacity values of more than 85 are reasonable and greater than 90 is considered 'good'.

Other materials

There are several other materials available to print on. For fine art prints, canvas is an obvious one. Many manufacturers of digital fine art papers also offer printable canvas. Hahnmuehle, for example, offers a fine 'Canvas Artist Matte' (340 g/m2, natural white). Less expensive and less convenient, you may use conventional canvas after preparing it with a coating described earlier.

Another material option is film and plastic. Film may be used either for backlit prints or to migrate for a moment from digital to analog printing, by using a film-print as a 'digital negative' and producing contact prints in wet darkroom using papers (((((such as Baryt or for platinum prints))))). There are two kind of film – clear and white. Both may be used with back lighting. For backlit film, you will have to search a bit. Kodak offers a 'Reverse backlit Film, 6 mil' which may be used with pigmented Epson Ultrachrome inks, as well as, with dye-based inks. There is also a film offered by Epson which appears to come from another manufacturer called Pictorico [44], who also offers a 'Photo Gallery Hi-Gloss Inkjet-White-Film' which has received notably positive comments in several publications. This film is also available in an A4 size. This material may be used to produce large format negatives for contact proofs. Also, have a look at the 'OHP Transparency Film' from the same company.

If you explore signmaker supplies, you may find even more varied material.

A problem with film is that it is difficult to locate ICC profiles for these media. Making your own profiles is not simple as standard profiling software states when using reflecting white paper as media.

As we have scarcely any experience with film, we won't go further into this.

Another printable material is fabric. Here, however, you will require specialized inks, and fabric needs special treatment before printing. Most desktop inkjets are poorly designed for printing on fabric. Most fabric printing is done on large-format printers. Still another kind of fine art prints may be done on rice paper.

Paper handling

The following section has little to do with print permanence, but mainly concerns handling of paper for printing.

Handling before printing First, there are some obvious points, such as, keeping the paper for printing dry, clean and dark – ideally the box in which it came. Not so obvious is that for printing paper humidity should not be too low (a room humidity of about 50–60 % is considered adequate) for printing.

As digital fine art printing paper is quite sensitive to oils and perspiration (which is acidic), you can wear thin cotton gloves when handling paper. This practice is standard when handling photographs, as well.

Figure 2-11: Use cotton gloves to handle your fine art papers and brush your paper before inserting it into the printer (Courtesy ***Monochrom Germany*** *[36])*

Preparing for printing Often there are loose, tiny paper particles attached to paper. These particles may clog your printer (print- heads and rollers). If they remain on the paper while printing and fall off later, you could have tiny white (or paper-colored) spots on your print. For that reason, we advise wiping the paper using a very soft brush immediately before printing.

Handling for printing Make certain you print on the coated side of a paper. Usually, you can see or feel the coating on the paper surface. On glossy and semigloss papers, the coated surface is most obvious – being the shiny side. With matte and similar papers, it usually is the

side showing the more prominent matte texture. If in doubt, test the paper lightly with a thumbnail. On the coated side, the nail will leave a clearly visible trace.

If you intend to use thick or heavy paper, first check to learn if your printer is capable of printing that paper thickness (see technical specification of the printer). Even if suitable, it may be necessary to manually guide the paper in the feeder. We recommend single sheet feeding any paper when fine art printing.

Only handle paper by its edges (or use cotton gloves).

After printing When retrieving a print after printing, avoid contact with the freshly printed surface. Place fresh print on a clean, flat surface, avoiding bright light (no direct sunlight) and let dry sufficiently. Drying time depends a bit on the kind of inks used and on media properties. Most dye-based inks take a bit longer to dry, but, for most inks and papers, one hour is a reasonable minimum time. Keep the print in a dust-free environment while drying!

If you intend to frame the print or do further protective coating, we recommend waiting at least 24 hours after printing. With RC papers (see page 2-20), you should wait significantly longer (e.g. a week) to give the paper a chance to do some outgassing.

If you use roll paper, you will have to flatten the paper to remove the curl from the paper roll. When the paper is dry, you may have to run it with a slight pressure over a table edge (the print's backside towards the table) to help remove curl. Still better is a device called *D-Roller*, produced by Glastonbury Design ([89]):

Figure 2-12: Using a D-Roller to remove paper curl

"A D-Roller will allow you to take the curl out of fine art papers that come from a roll. These papers are used in the fine art and photography digital print market. Traditional fine art papers may also be D-Rolled to take the curl (roll set) out of them. Papers may be D-Rolled prior to or after printing with no drying time needed for the inks." (See Uwe's short note on the D-Roller at [88]).

Storing your prints Storing digital prints is the same as storing silver-halide-based photos. Keep them clean, dry and (when not hanging during presentation), dark. When stored for archiving, be sure their container is acid-free and it is recommended – as is well known with traditional photo albums – to isolate prints by separating sheets with acid-free paper. There exist special tissue papers for this purpose available that are 'buffered' (meaning they have a pH-value of about 8, so they can absorb/neutralize acidic components from air pollution).

Note: You may find a useful paper/glossary (PDF file) called "A–Z of Paper: Interesting Facts on Paper" by Hahnemuehle under [85].

Suitable digital fine art papers

There are endless papers available. Here, we only list papers that we have some experience with. You may classify papers according to their surface and make:

- Matte papers
- Matte fine art papers
- Satin/glossy coated rag papers (new emerging category)
- Satin papers with a very soft gloss finish
- Luster/pearl papers
- High gloss papers
- Specialty papers and canvas

Matte papers

- **Epson Enhanced Matte**: Very nice, smooth paper that is even quite inexpensive. But be aware that the paper may turn yellow due to use of quite strong brighteners. This paper is also very thin, so that in some cases warping may occur.

Matte Fine Art Papers

- **Hahnemuehle Photo Rag / (Satin)**: Very popular, but expensive. Both papers are available in different grammages (from 188 g/m² to 460 g/m². Photo Rag is also well suited for B & W prints. You have to watch for scuffing and cotton dust and should in any case wipe the paper with a soft brush before printing.
- **Somerset Velvet Photo Enhanced**: Very nice paper. One of our favorites.
- **Moab Entrada Natural**: Excellent, reasonably priced paper.
- **Epson Ultra Smooth**: Top paper, that is also archival. Watch for cotton dust, however.
- **Crane Museo II**: Very fine paper.
- **Arches**: Expensive paper with a very good reputation. We have not had a chance to check it out, yet.

Satin/glossy coated rag papers (new emerging category)

- **Crane Museo Silver Rag**: Very new paper.
- We expect that many papers will follow in this category.

Satin or soft gloss papers

Most of these papers have a slightly plastic feel. More an issue in open portfolios than behind glass.

- **Epson Premium Semimatte**: Nice surface for a satin paper.
- **HP Premium Plus Satin**: Very nice satin surface.
- **Epson Premium Semigloss**: Comes close to the Epson Premium Semimatte paper, but maybe not quite as nice.

We expect new papers in this category to show up in the very near future, as the demand for fine art inkjet papers increases.

Luster/pearl papers

- **Epson Premium Luster:** popular paper with good Dmax. Some don't like the surface which is no problem behind glass.
- **Ilford Galerie Classic Pearl**: a popular alternative to Epson Premium Luster

High Gloss papers

- **Epson Premium Glossy:** Some bronzing can show. The bronzing may largely be reduced using the new Epson **K3** inks.
- **HP Premium Plus Gloss**: Very nice glossy paper surface.
- **Pictorico Photo Gallery Hi-Gloss White Film**: Very special paper, that has an ultra smooth surface and also a lot of contrast and depth. It is rated to be very archival.

Specialty papers and canvas

- All sorts of canvas
- Rice paper
- Many more variations

Table 2.1: Standard paper sizes

Format/Name	Metric size	U.S. equivalent
Metric names		
A6	10.5 × 14.8 cm	4.13 × 5.82 inches
A5	14.8 × 21.0 cm	5.82 × 8.27 inches
A4	21.0 × 29.7 cm	8.27 × 11.69 inches
A4 Plus	21.0 × 33.0 cm	8.27 × 13.00 inches
A3	29.7 × 42.0 cm	11.69 × 16.53 inches
A3+	32.9 × 48.3 cm	13.00 × 19.00 inches
A2	42.0 × 59.4 cm	16.53 × 23.38 inches
A1	59.4 × 84.1 cm	23.38 × 33.11 inches
Ao	84.1 × 118.9 cm	33.11 × 46.81 inches
U.S. names		
Executive	18.4 × 118.9 cm	7.1 × 10.5 inches
A (Letter)	21.6 × 27.9 cm	8.5 × 11.0 inches
Legal	21.6 × 35.6 cm	8.5 × 14.0 inches
B (Leger, Tabloid)	43.2 × 27.9 cm	11.0 × 17.0 inches
Super B/Super A3	33.0 × 48.3 cm	13.0 × 19.0 inches
C (Broadsheet)	43.2 × 55.9 cm	17.0 × 22.0 inches
D	55.9 × 86.4 cm	22.0 × 34.0 inches
E	86.4 × 111.8 cm	34.0 × 44.0 inches

Chapter 3

Color Management for Printing

Camera: Olympus E20P

With photos, we usually work in color. Thus, it is essential that the color seen on our monitor closely matches that seen by the camera when a photo was taken or that of a slide recorded by a scanner.

Likewise, when white balancing, fiddling with color saturation or performing other color corrections or contrast enhancements, we want to be sure the color we see on a monitor represents the color values of our image, and that when we finally print the image (after optimization and enhancements are complete), the colors in our

print will closely match those we view on our monitor. This is what *color management* is all about. Of course, in order to do efficient color work, it is essential to understand the basics of color and color management.

Color management is one of the most demanding subjects in digital photography, and has, itself, been the subject of entire books. Because of this, we provide only a short introduction to color management with a focus on those parts important to our workflow. There are several good books on color management, such as *Color Confidence* by Tim Grey ([1]) and *Real World Color Management* by Bruce Fraser ([2]).

3.1 Understanding different color models

Photoshop supports several different color models. A color model defines how colors in an image are described using numerical values. The main color models for photographers are these:

- RGB
- LAB
- CMYK
- Grayscale

Photoshop provides additional color models but are rarely used by photographers, so a discussion of them is beyond the scope of this book. These include *Bitmap* for pure black and white (bitonality) images, and *Index mode*, used primarily for web graphics (if you can live with fewer than 256 different color values). *Duotone* is used with grayscale images and allows the addition of a second color giving a print more depth.

Color depth: Returning to the term *color model*, you may use either 8-bit (one byte) to specify the amount (or percentage) of a single value (e.g. red) or 16-bit (2 bytes). Thus you may have your image in 8-bit or 16-bit mode. A different bit length is possible, but not supported by most applications. Using 16-bit doubles the space needed to store values, but gives you more headroom when it comes to differentiating color values and allows for more precise calculations with less rounding errors. Using 8-bit, the value of a single component may vary from 0 to 255 (using integers). Using 16-bit, the range runs from 0 to 65,536 (actually only 15-bits are used in Photoshop, so

the range becomes 0 to 32,768). Though we recommend using 16-bit whenever possible and reasonable, for most explanations we use 8-bit values (0–255). This is common practice. For most issues in color management, it doesn't matter which mode you use. When producing final output, e.g. printing, you will be required to reduce your image to 8-bit mode, since nearly all real devices can't actually produce more than 256 different shades of a color (taking into account a combination of the three primary colors of RGB, this adds up to 16,777.216 different colors). Our eyes can only differentiate about 120–200 different shades of a color, depending on illumination. During the phase of color optimization, however, where a large amount of color shifting and transformation plus lots of calculation of color values is done, 16-bit is the preferred mode.

RGB color model

All colors in the RGB color model are created from three primary colors: red, green and blue. RGB is the color model most commonly used today in digital photography, and we will perform our workflow mainly in this mode. RGB is an *additive color model*, meaning that the sum (addition) of all three basic colors at full strength (100 percent) will add up to pure white.

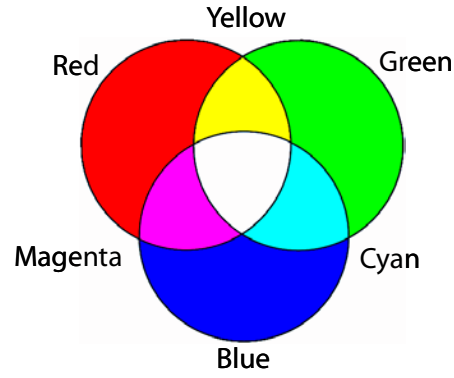


Figure 3-1: The RGB Color Model

Triple (0, 0, 0) defines black while (255, 255, 255) is bright white (Pure white should hardly occur in any photo).

As you will learn a bit later, pure RGB values without an additional reference to the device or color space these values are used in, do **not** define colors in an unambiguous way.

LAB color model

The *CIE-LAB color model* (often spelled Lab, LAB or L*a*b*) separates colors (chroma, A+B) from the detail and brightness (luminance, L) in images. As in RGB, Lab uses three basic components to build (or describe) a color: *L* (for Luminance), ranging from Black (0 = no light) to white (100), and two color axes: *a* and *b*. The a-axis is Green to Red and the b-axis, Blue to Yellow.

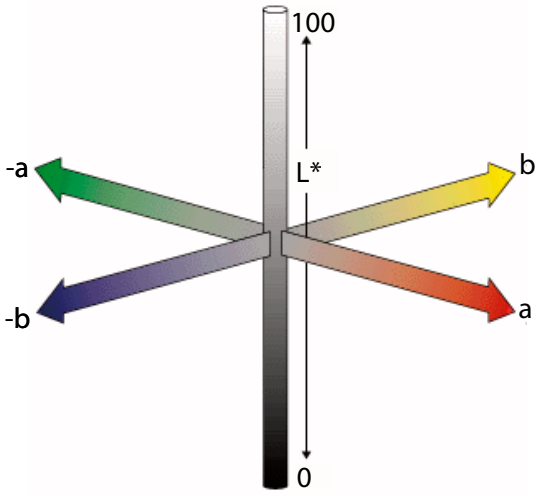


Figure 3-2: LAB color model

CMYK color model

The CMYK color model uses four primary colors to define a color: Cyan (C), Magenta (M) and Yellow (Y) and Black. CMYK was designed for printing, where incoming light is reflected by the print.

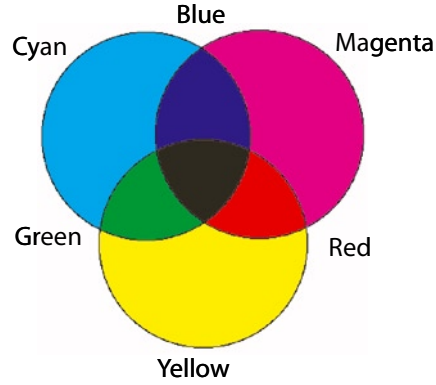


Figure 3-3: CMYK Color Model

CMYK is a *subtractive color model*, as each of these colored inks absorbs (subtracts) a certain spectrum of light. As you see in figure 3-3, mixing cyan and magenta gives you blue, and when you add magenta to yellow you get red. In theory, the combination of the colors C, M, and Y alone should be sufficient to produce black, but due to certain impurities in inks, they produce a dark muddy brown instead. To solve this problem, a fourth color, black, is added, and is called the *key color* (K for short).

Although CMYK is an important color model for a printing press, it is not used much in digital photography. Though inkjet printers are technically CMYK printers (most are even CcMmYK with additional light Cyan and Magenta inks), they provide an RGB interface to the user, and transformation from RGB to CMYK is done by the printer driver in an almost transparent way.

We rarely use the CMYK color model in our workflow. Even when intending images for printing preparation which requires CMYK, you should stick with RGB mode images whenever possible and resort to an RGB to CMYK conversion as the very last step (some additional sharpening and some slight increasing of saturation may be required afterwards for the final touchup). Working on photos in CMYK mode has these disadvantages:

- CMYK images are larger than RGB (with four color values per pixel instead of three with RGB).
- Some photo filters don't work in CMYK mode.
- The CMYK color space usually contains fewer colors than most RGB color spaces. Thus, when you convert from RGB to CMYK, you may lose some colors, and there is no way to retrieve them should you want to later use your image for something such as lightjet printing (used by photo services to output your image on photographic paper) or a digital presentation using a monitor using RGB colors.

Grayscale mode

Photoshop also works with images in pure black and white (B&W) or in grayscale. However, when working in grayscale, the color of a pixel only describes a single (gray) value. Consequently, even when intending to produce a B&W photo (grayscale photo), we use RGB mode, to preserve color information. This allows to give the B&W print still some tint.

When using Photoshop's bitmap mode, a picture has only two possible color values: black or white; no gray. Bitmap mode is rarely used with photographs, and most imaging techniques and filters do not support bitmap mode.

HSB/HSL color model

There are two other color models, which are not explicitly supported by Photoshop but nevertheless show up at several places – HSB and HSL. The HSB model uses three components to describe colors: ***H**ue, **S**aturation* and ***B**rightness*. In the HSL model ***H**ue, **S**aturation* and ***L**ightness* are used. These models are explained at page 3-42.

Color spaces

A *color space* is the total range of colors (or color values) real devices, such as a monitor or printer or a virtual device (such as a *theoretical average monitor*, represented by the sRGB color space) can record or reproduce. This range defines the *gamut* of the device.

Every real device has a unique color space, and even identical devices (same make and model) have slightly different color spaces, e.g. due to different age, production tolerances and so on. These differences increase with variations in user-selected hardware- or software-settings, such as different monitor resolution, different printer inks or paper, or even a different brightness setting on a monitor.

To improve our ability to work with color, the International Color Consortium (ICC for short, see also [25]) and some other companies (e.g. Adobe, Kodak, Apple) have defined *virtual color spaces* representing the gamut of a virtual, rather than a real device. We will see later, what the advantage of these virtual, standardized color spaces really are.

3.2 Understanding color management

Color correction and *color management (CM)* are two of the most important yet difficult areas to master in digital photography. As stated earlier, the goal of color management is to ensure that the photo you view on your monitor looks as much as possible like the print received from your printer or very much the same when sending it to a photo service which reproduces it using a lightjet printer. Color management helps reproduce colors as truthfully as possible across a broad range of different devices. As an identical reproduction is often impossible due to different ways various devices produce color, you should at least be able to predict the color you'll get when printing from the color you see on your monitor.

The ability of a color-managed application to show (simulate) on your monitor the colors and the impression that an image will have when printed on a specific printer or other output device is called *soft proofing*. When you actually print using the same inks and the same paper used for final output, this is called *hard proofing*.

Why you need to understand color management

If you post a photo on the web and ask different people to discuss its color quality, responses will be altered by the fact that when the image is displayed on different monitors (without color management), the resulting image will display colors at least slightly differently on all monitors. Viewers will actually see different versions of the same photo. In fact, monitors may not even be capable of rendering some RGB values at all. It is the domain of color management to significantly reduce the problem described here.

The challenge Your challenge is to have a monitor display the correct impression of how a certain photo would print on a color printer. The latest inkjet printers produce amazing results, but without proper color management, color printing remains trial and error. You end up changing the printer's color settings for every print, with usually hardly satisfactory.

The solution The solution to this color problem is to determine the color characteristics of a device, and to take those characteristics into account when reading colors from an input device or when sending color to an output device. Additionally, you put a tag on color images that defines how the color values of the image are to be interpreted.

ICC profiles

An important concept of color management is the production of a standardized description of a device, called an *ICC profile*; the format of these profiles is defined by the ICC. The ICC color profile describes a device's color characteristics, such as the colors the device can record or reproduce and the values recorded for a perceived color (input device), or the values you must send to an output device to produce a certain color. These profiles are available from the device manufacturer (usually called *generic profiles*), or you produce your own using special profiling hardware and software. A profile produced for your specific device is called a *custom profile*. Almost all color management systems today use ICC profiles. With the help of such a profile, the color values required to produce a specific color on device A (e.g. a monitor) can be translated to values that will

reproduce that specific color on device B (e.g. a printer) as closely as technically possible. It also describes the gamut of the device.

Note: While a raw RGB value does not define color in an absolute way, the color produced is very much dependent on the device used or on the device that recorded that value. An RGB value in the context of a color space (defined by the ICC profile of the color space) however, does define an absolute color!

Note: Because most people use their monitor as their soft proofing device, the first step toward complete color management is to profile your monitor.

Let's return to the situation when receiving a sent image that (without color management) displays different colors on different monitors. With the help of the input profile, a color management system may correctly interpret the RGB values of the (input) image and, with the aid of an ICC profile for your monitor, may transfer them to color values producing (nearly) the same color on your output device. How this is done, we will see in the next section.

What is a color management system?

A color management system (CMS) is a set of program modules to handle color translation. These modules are often part of the operating system but may be provided by applications, as well (Adobe does this). If an application is used to display or print a color image, it calls up these functions and hands over the image values and ICC profile information and tells the CMS what function should be performed. The central part of the CMS is a module called color management module (CMM). This does the calculations needed to translate (transform) a color from color space A to color space B. Here's how it works:

1. First, the *color management module (CMM)* translates the device-dependent color values of the image to a device-independent color space, using the description of the source ICC profile. Now the color values of the image are in Lab color space, which is device-independent. This intermediate space is called *transfer color space* or *profile connection space* (PCS for short).
2. Next, these LAB values are translated to color values that will produce a color on the output device that is as close to the origi-

nal color impression as possible. If the output device cannot produce the very same color, the CMM will try to find a close match. How the best match is achieved, is determined by the translation intent (explained at page 4-14), also called *rendering intent*.

The ICC profiles used in this scheme are actually simple translation tables. They support translation from device-dependent color values to device-independent color values (and vice versa).

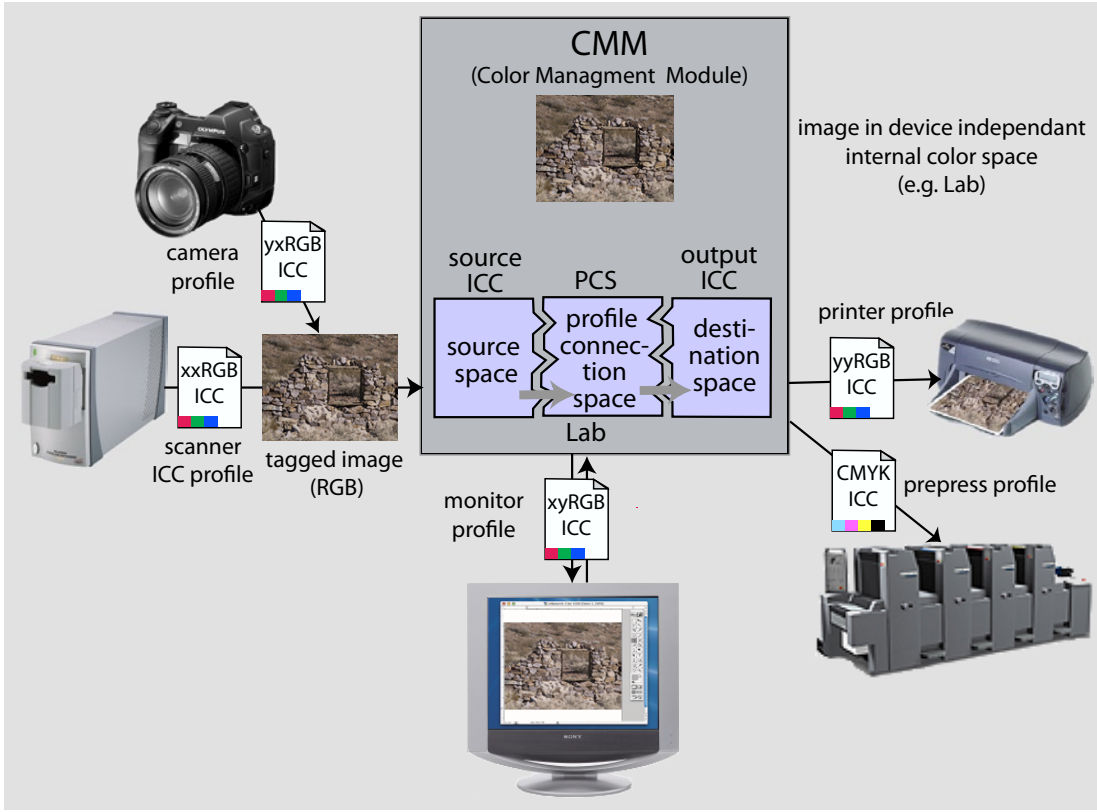


Figure 3-4: How color profiles function with a color management system

Photoshop, and other applications supporting color management, embed the ICC profile data within the image file, and the files with this embedded information are called *tagged files* (or *tagged images*). When you pass the tagged image along, the profile information is passed along as well. You should be aware that not all image file formats can include ICC profiles. While TIFFs and JPEGs can, GIFs cannot (GIF has an unacceptable color depth anyway).

Note: Avoid applications not using or creating these embedded profiles and also do not support use of monitor profiles. The color of the image they display on the monitor or print may or may not be correct or even close to the true colors. You will not know. Some applications may even remove the profiles from your image when editing without telling you.

Color working spaces

It is a bit tedious to work with a large number of different device-dependent color spaces. This is why virtual, standardized color spaces were defined. They do not describe the gamut of a real device, rather for an abstract (virtual) device. There are several different spaces for each of the color models (RGB, Lab, CMYK). They range from narrow to broad gamut. For example, for the RGB color model, there is (from narrow to wide) sRGB, Apple RGB, Adobe RGB (1998), ECI-RGB and Pro Photo RGB (and several others).

To eliminate a specific working space (including its ICC profile) of your input device, you usually convert an image from the original input color space to a standardized color space and continue to work on this image using this working space. With digital photos, you may accomplish this conversion using the RAW converter.

Why define several working spaces for a color model? These spaces differ mainly in the color range (their gamut) they cover. In some workflows, it is advantageous to use a narrow color space, while in others, a wide space is better. If your input device has a wide gamut (such as a digital camera), you should use a work space with a wide gamut if intending to produce output for several different methods (e.g. inkjet printer, lightjet printer, monitor, etc.). If you convert your image to a working space with a narrow gamut, you may lose some colors that could be reproduced by some output devices. If, however, you use a working space with a very wide gamut, the numbers (bits) representing color values may not be sufficient to differentiate the many different colors your gamut allows (with 8-bit there are only 256 discrete values available). Many of these discrete values may be lost because your image may never have colors that extend to the outer edge of the theoretical gamut of the space. This may become worse if you must do a lot of correcting, rounding and transformations. For this reason, we recommend using 16-bit mode, when you intend to use a color space with a wide gamut.

The following list shows some of the most important color spaces for photographers:

- **sRGB**: This color space was designed to be used with monitors, and is probably a good one for photos to be presented on the Web. It defines a gamut that can be displayed by the average monitor, a relatively narrow color space. Though many DSLRs allow you to produce images using this color space, sRGB color space is much narrower than the color space cameras can see and record.
- **Adobe RGB (1998):** A color space very popular among Photoshop users. It has a larger gamut than sRGB and covers most printable colors. This is the color space we prefer for digital photos.
- **Pro Photo RGB:** This color space was defined and is supported by Kodak. It provides a very large gamut and should only be used when working with a color depth of 16-bit. Of the RGB working spaces mentioned here, it is the only one that can hold the full camera gamut. It is also the internal working space for Adobe Camera Raw.
- **Apple RGB:** This color space was defined by Apple Computer and is commonly used with Macintosh systems. Its gamut is wider than that of sRGB but smaller than that of Adobe RGB.
- **ECI-RGB:** This color space was defined by ECI, the European Color Initiative – a group of companies attempting to define color production standards in Europe. The ECI-RGB color space was designed to include all colors that may be reproduced by printers. Its gamut is somewhat wider than that of Adobe RGB and includes some green colors that can be reproduced by many printers (inkjet and offset, as well as gravure), but which are not part of either sRGB or Adobe RGB (1998). ECI-RGB is the standard RGB color space within the European prepress industry and serves as the European alternative to Adobe RGB for prepress work.
  As the ECI-RGB profile is not part of Adobe's Photoshop distribution, you have to download this profile from the Internet (www.eci.org).

Visualization of color spaces

Color spaces are actually three-dimensional (L-, A-, B-axis). The profile shown in figure 3-5 is that of sRGB, using the ColorSync utility of Mac OS X (there is a similar utility called *MS Color Control Panel* for Windows XP, that you may download [32]). In figure 3-5 the gray outer space shows the gamut of Adobe RGB (1998) and allows comparing these two color spaces. As can be seen, Adobe RGB is a superset of sRGB.

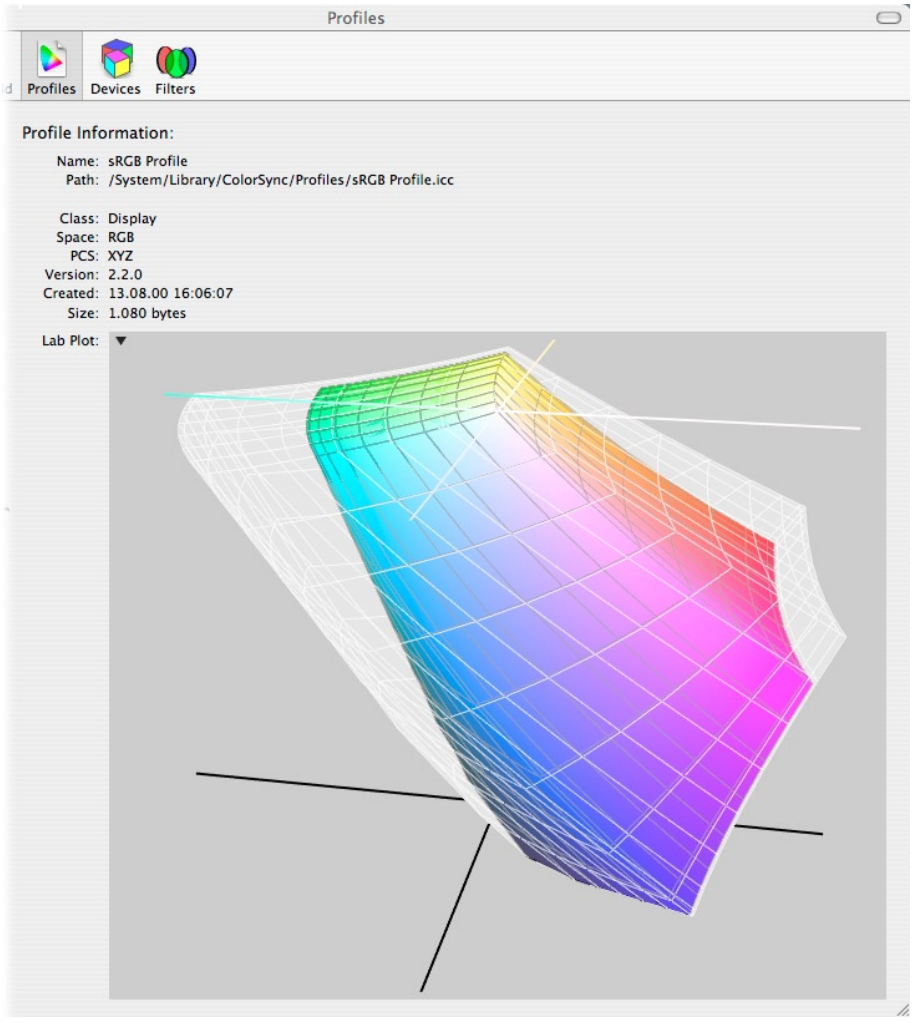


Figure 3-5: 3D diagram of sRGB (color) and Adobe RGB (1998) (gray shape)

The industry also uses some form of 2D charts to display color spaces. The color space plot shown in Figure 3-6 was generated with the GretagMacbeth Profile Maker Pro 4.1 Profile Editor.

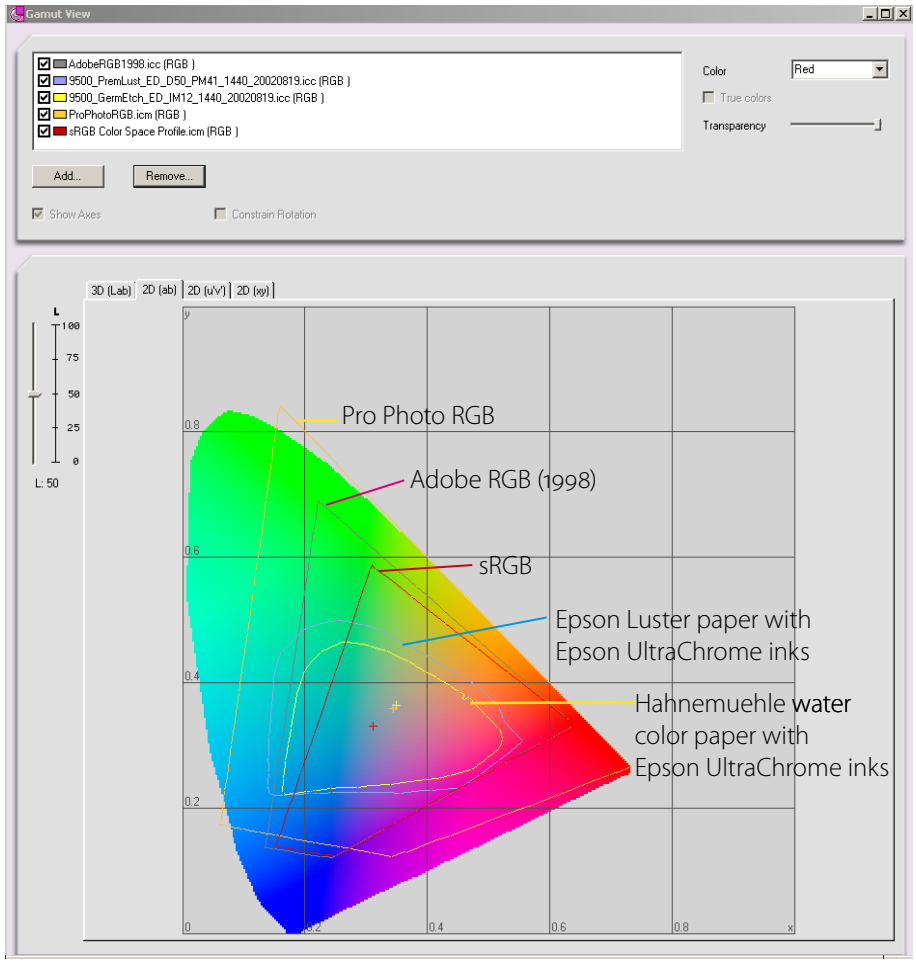


Figure 3-6: Gamut Display (using Profile Maker Pro 4.1 Profile Editor)

As seen in the diagram of figure 3-6, Pro Photo RGB is extremely wide, while Adobe RGB (1998) is much smaller and sRGB is very narrow.

We often used '**Hahnemuehle German Etching watercolor paper**' when printing with our inkjet printers. The gamut that may be reproduced using this paper using **Epson's UltraChrome inks exceeds** sRGB but fits into Adobe RGB.

The color space of the '**Epson Lustre paper' has a much wider** range than that of "**Hahnemuehle watercolor paper" (no surprise** here) and exceeds both sRGB and Adobe RGB (in some blues and greens). If you have ICC profiles describing different printing sets (combinations of printer + ink + paper), a display like the ones shown above allow you to compare the gamut and thus the color richness you may achieve using different papers.

Color space mapping

When images need to be converted from one color space to another, for example, when displaying an image on a monitor, the image is transformed from its source color space (device color space or working color space) to that of the output device (your monitor in this case). In most cases, the gamut of the source and the destination are different, so some color mapping has to take place. This transformation is performed by the color management module (also called the color management engine).

The main question is: What to do with those colors of the source space not present at the destination space? Because there are several ways to handle this problem, ICC has defined four different ways of mapping, called *intents*:

Perceptual (also called *Photographic*): If the gamut of the source space is wider than that of the destination space, all colors are compressed to fit into the destination space. If the gamut of the source space is smaller than the destination space (all colors of the source are present at the destination space), a one-to-one mapping takes place (all colors keep their original appearance).

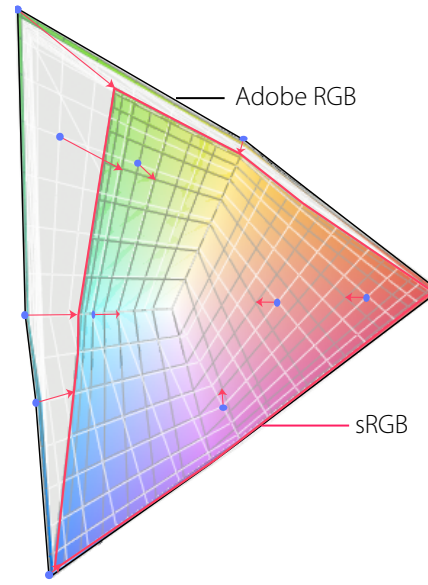


Figure 3-7: Perceptual gamut mapping from Adobe RGB to sRGB

When mapping from a wider space to a smaller space, Perceptual mapping usually shifts colors to a bit less saturated and somewhat lighter colors, but the overall impression of the image is preserved (different colors keep their relative color distance). When the white point of the color spaces are different, a white point mapping takes place. Perceptual mapping is one of the two intents used when converting photographs (the other being *Relative colormetric*).

Relative colormetric: When mapping from a wider color space to a smaller color space and a color in the source space is not present at the destination space, it is mapped to the closest color at the desti-

nation space, usually at the border of the space.

With this mapping, two colors, different in the source space and not present in the destination space may be mapped to the same color in the destination space (usually residing at the border of the that space). This could result in some color clipping or banding. The white point of the source space is mapped to the white point of the destination (if they differ), and all colors are adapted relative to the destination white point.

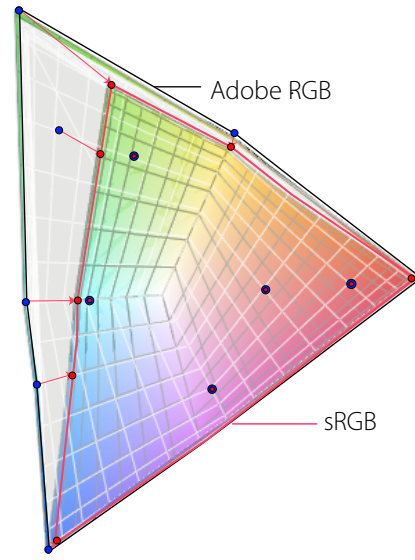


Figure 3-8: Relative colorimetric mapping (Adobe RGB to sRGB)

This intent is useful for photographs, and should be used when the source and destination spaces have a similar gamut with lots of overlap, or if most of the colors in your image (which may not use the full gamut of the source space) have an identical color in the destination space. In this case, most colors remain unmodified when transformed. This intent is used implicitly when colors in an image are translated to colors on your monitor.

Absolute colormetric: This intent is like a relative colormetric, where colors present in both color spaces are mapped 1:1, and colors that are *out of the gamut* (a color of the source space, that is not present in the destination space) are mapped to the border of the destination space. This mapping is particularly useful if you wish to use your output device (say the monitor) to simulate the behavior of another device. There is no mapping for the white point.

Use this intent **only** for soft proofing: When you want your monitor to display what your image will look like when printed on an inkjet or with offset printing. In this case, the monitor simulates the white color of the paper.

Saturation: This intent tries to map an out-of-gamut color to a color of the destination space with the same saturation, even if the color has to be shifted significantly. Use this intent when converting logos and colored diagrams from a larger color space to smaller one. With

photographs, it is of no use as it tries to keep the visual difference of two colors but not their color impression. Some third-party profiles however (mis-) use this intent for a special color mapping that tries to map saturated out-of-gamut colors retaining the saturation as best as possible without a noticeable color shift and may be for photos.

3.3 Creating device profiles

The introduction above emphasizes the importance of using accurate device profiles. As most of our digital work is done using the monitor, when setting up a color managed workflow we need to consider monitor profiling as our most important task. In this section, we turn our attention to building a device profile. When profiling a device, there are normally two steps:

1. **Calibration.**
   The aim of calibration is to define a *standardized state* for the device, setting its controls so that it is in a state as close to this defined state as possible. For example, when calibrating a monitor, you manually set the controls of your monitor to achieve a certain *luminance* (brightness of your monitor's white) that has proven to be good for color work. Also, you set a *white point* conforming to an industry standard, such as D50 or D65 (color temperatures of 5,000 or 6,500 Kelvin respectively). The *white point* of your monitor is a mix of R, G and B that will represent *white*.

2. **Characterization.**
   When characterizing a device, a *target* is recorded by the input device or sent to an output device. A target (test chart) is a pattern of color patches with known color values. By comparing the color values recorded by the device (such as a scanner) to the known color values of the target, the profiling program can calculate a device's *color profile*. The profile is essentially a translation table of device-dependant color values to device-independent color values (with input devices) or vice versa (with output devices). As an example, if the profile is for an input device, it translates device-dependant colors seen by the device into the device-independent profile connection space (PCS, which is CIELAB space). If, on the other hand, it is for a profile of an output

device, the table provides translation from the profile connection space to the device-dependant colors of the output device.

To perform either step it is advisable to use a hardware device to measure color. When calibrating monitors, the device could be either a colorimeter or a spectrophotometer.

As the focus of this book is on fine art printing, we provide a very brief overview of profiling, with only a bit deeper discussion of profiling your monitor and your printer(s).

Camera profiles

There are two types of camera profiles: *generic camera* and *custom camera profiles* which profile specific cameras. All good RAW converters come with quite good generic profiles. Some of them (e.g. Raw Shooter and Capture One) also support custom profiles. For some RAW converters you may also buy good third party camera profiles.

Creating your own camera profiles can be very tricky since targets must be shot under highly-controlled lighting conditions. Additionally, individual cameras of the same model can vary significantly (certain cameras vary more than others within type and brand). For more details on camera profiling see one of our RAW conversion books ([22] or [23]).

Printer profiles

There is no single profile for a printer. A printer profile is always specific to that printer using a specific paper, ink set, and a specific driver and its settings (such as the same DPI). To make life interesting, profiles for different types of printing paper also vary significantly.

When profiling a printer, a target is printed using precisely the printer settings, ink, and paper that the profile is intended for. Once the print has dried (anywhere from 1 to 24 hours) the color values of the print are measured using either a spectrophotometer or a profiled scanner (less accurate). By comparing known values of the color patches of the target to those of the measured patches of the print, the profiling software produces the printer profile.

Fortunately, you don't need to invest in a costly spectrophotometer and profiling software; you can use several profiling services, which do this job for you. Look up "printer profiling service" at Yahoo or Google. For more details on printer profiling see section 3.6.

3.4 Profiling your monitor

As stated earlier, an accurate monitor profile is the basis for serious color-managed workflow. When calibrating your monitor, you have a choice of doing so by eye or with specialized hardware.

When profiling your monitor, begin by turning it on and leaving it on at least 30 minutes before beginning any calibration. To perform the calibration, follow the instructions provided by your choice of tool, whether calibrating by eye or using hardware-based tools as those discussed below.

Be aware that room lightning, the color of your walls and desktop and even your clothing can influence precise calibration.

Calibration by eye

Photoshop for Windows comes with a utility called *Adobe Gamma* that lets you calibrate your monitor. With Mac OS X there is a similar utility called *ColorSync Calibrator*. Both utilities use your eyes as their measuring instrument.

Hardware based calibration

Although calibrating your monitor by eye is better than doing no calibration at all, if precision is important to you, you should use a hardware-based color measuring device (a color spectrophotometer or colorimeter) to achieve much more precise results. While the software and hardware for monitor profiling were once quite expensive, there are several packages currently available for between USD $100 – $300 for a complete kit. Your choices include: GretagMacbeth *Eye One Display 2* (see [27]), ColorVision Spyder and Spyder Pro products (see [28]), and MonacoOPTIX from Monaco Systems (see [29]).

We use and recommend GretagMacbeth Eye-One Display 2 and Monaco Optix .

The entire calibration and profiling process will take you about 10 minutes. Once a good calibration is achieved, the next calibration will be much faster.

Calibration settings

As there are several options when calibrating and profiling a monitor, you have to decide which settings to use when starting your calibration. Without going into too much detail, we recommend using the following values:

White point	6500 K (D65)
Gamma	2.2
Luminance	100–150 cd/m²

We recommend these values even for prepress work (where a white point of 5 000 K is the standard) and even if you work on a Mac where a gamma of 1.8 is traditional.

Calibrating and profiling using Eye-One Display 2

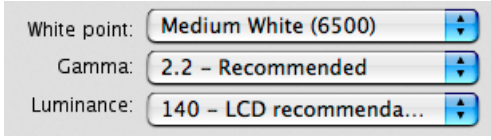
The Eye-One Display package from Gretag Macbeth ([27]) includes software (Eye-One Match) for calibrating and profiling monitors, as well as a sensor (colorimeter). It supports Windows, as well as, Mac OS and allows the calibration of CRTs as well as LCDs and laptop displays. To use it to calibrate your monitor:

1. Launch Eye-One Match (EOM) and select the monitor from the list of devices you can profile. We recommend using Advanced mode.

Eye-One Match
Eye-One Match 3
Select the device you wish to profile
Help
Monitors
This is the online help! It will guide you through every step of the profiling process.
Choose the device you wish to profile from the options on the left. Browse through the help to learn more about the different options.
Select your profiling mode and click the right arrow.
Easy
Advanced

Figure 3-9: Startup screen of Eye-One Match: Select the monitor to profile

2. Select the type of monitor you intend to calibrate (LCD, CRT, or Laptop), then Click ▶ to continue.
3. The first task is to calibrate the sensor (not your monitor). Follow the instructions given on the screen. (Help will provide you with additional information.)
4. Select your target calibration settings. We recommend these values:



◀ *Figure 3-10: Recommended settings for your monitor calibration*

▶ will take you to the next step.

5. Attach the sensor to your monitor using either the suction-cup (if calibrating a CRT) or by attaching the lead weights to your sensor cable and letting them dangle on the backside of the monitor. If calibrating an LCD, you may have to tilt the monitor backward a bit, so that the sensor lies flat on the screen.

◀ *Figure 3-11: Eye-One Display colorimeter*

6. Begin the calibration phase using the controls on your monitor, if your monitor has them. (Skip this step if you are calibrating a laptop or LCD without controls and continue with step 8). You will set the contrast control to maximum and then slowly reduce it until the green arrow resembles the black one. Don't worry; Eye-One Match will guide you through this calibration.

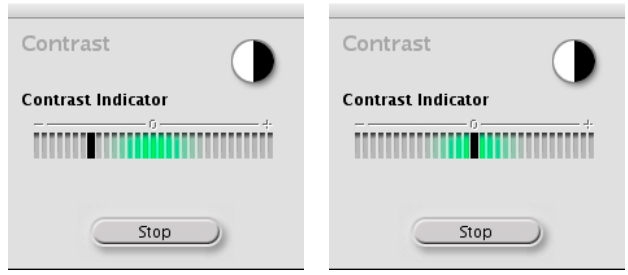


Figure 3-12: Use your monitor dial to bring the contrast marker near the zero value.

7. Press Start to have EOM begin measuring the contrast values, then Stop and ▶ to begin calibration of the RGB controls. This step will set the control dials so that the monitor's white point is set close to the intended color temperature (6,500 or 5,000 Kelvin). This may be achieved either by adjusting an OSD (Online Screen Display) setting on the monitor, or by setting the monitor's R-, G- and B-controls, if any. In this step, all three colored bars should be in the green area for optimal calibration. (The Eye-One Match screen will give you useful feedback.)

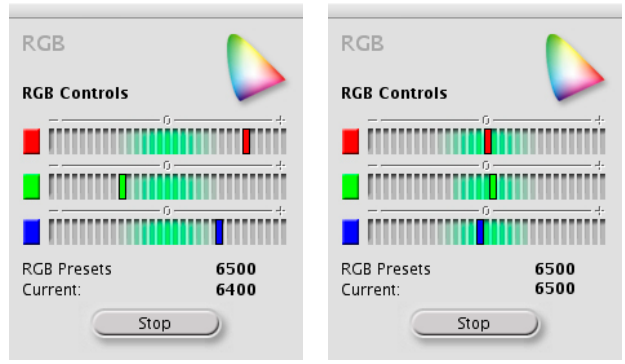


Figure 3-13: If your monitor has RGB controls you should try to set your target white point.

Next, set luminance using your monitor's brightness controls.

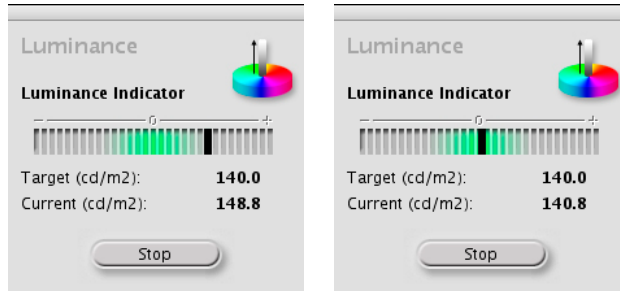


Figure 3-14: Set the luminance using your brightness control of the monitor to a target value of 120–150 cd/m².

8. This finishes the calibration phase, and Eye-One Match will start the actual characterization. It will display a number of color patches and measure their values (which should take about five minutes). You won't need to do anything while this process runs.

9. Once the characterization is finished, Eye-One Match will display the values used and display a diagram of the resulting color space (see figure 3-15 below).

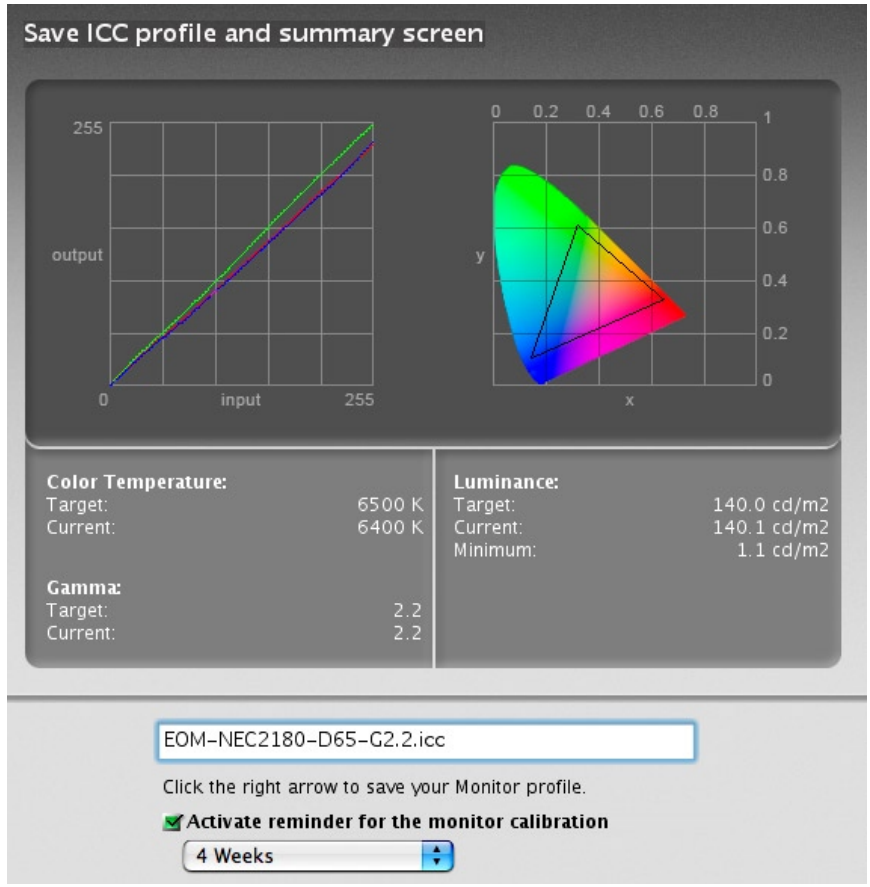


Figure 3-15: When finished, EOM shows the profiling values and the monitor color space. Enter a descriptive profile name.

EOM will also prompt you for a profile name. Choose a descriptive name reflecting the tool used, the make of the monitor, as well as the values used. For example, if your are using EOM to calibrate an NEC 2180 monitor with X values, a suggested name might be "EOM-NEC2180-D65-G2.2". You may also want to include the date.

Eye-One Match will save the ICC profile to the appropriate folder (depending on your operating system), and will immediately make it the active and default monitor profile. Running Windows and having Adobe Gamma installed, you should move Adobe Gamma out of your start folder to prevent it interfering with the correct loading of the new monitor profile when Windows starts up.

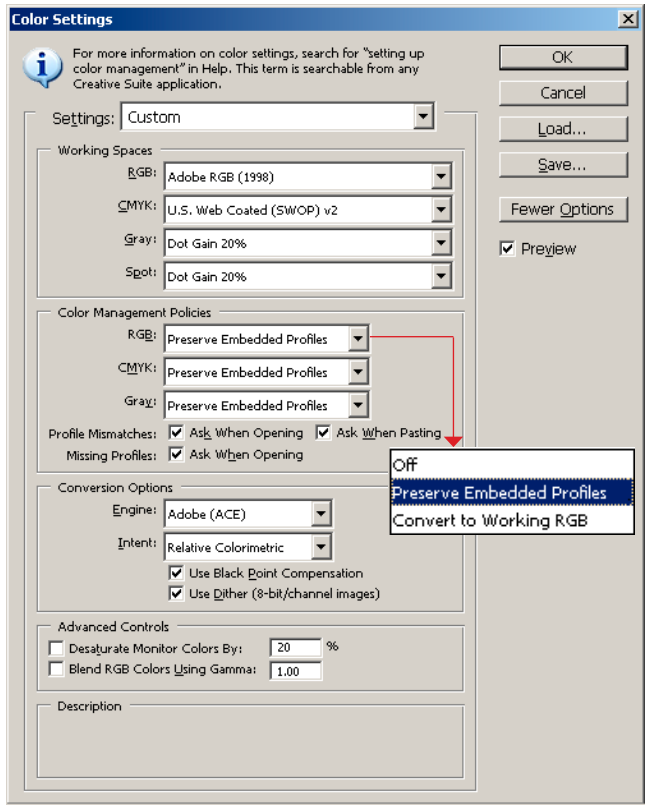
Once you have completed these profiling steps, do not change any monitor settings without re-calibrating. You should plan to re-calibrate your monitor about once a month.

3.5 Photoshop color management settings

Before beginning to work with Photoshop, set the program up with your personal color management preferences. The way color settings are made is similar with all Adobe applications since Adobe Creative Suite 1 (CS1). When using CS2, you may use centralized color settings. These settings will be used (by default) by all other CS2 applications, as well. With CS2, the settings may be done in Bridge.

Photoshop probably offers the most advanced color management support of any application. For that reason, its color settings show many different options and parameters.

To begin setting your color management preferences, select Edit ▸ Color Settings to open the color setting dialog. Figure 3-14 shows how we set the Color Settings in Photoshop.



◂ *Figure 3-16: Photoshop color settings*

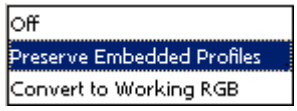
Working Spaces

Here you define your default working spaces for the various color modes (RGB, CMYK, Grayscale and Spot Color). The RGB working space is the one that is important for photographers. We use either Adobe RGB (1998) or Pro Photo RGB.

The CMYK working space is important only when converting RGB images to CMYK. The profile selected here is used as the destination color space. In the United States, U.S. Web-Coated (SWAP) **v2** is the best choice if your print shop does not provide you with different instructions.

Dot Gain 20 is usually appropriate (and the Photoshop default value) when you work with grayscale images. If your print shop gives you different values, use them. The same is true for spot color.

Color Management Policies



With Color Management Policies, you define the default action that Photoshop takes when you open an image or paste pixels into your opened image and no profile is embedded or the color space of the image is not the same as your current working space. Again, you can set this for RGB, CMYK, and grayscale images.

In most cases, Preserve Embedded Profiles is the best choice. The only reasonable alternative is to choose Convert to Working. Selecting Off rarely makes sense in a color-managed workflow. If you choose Off, color management will still take place. With off, the colors of the image will be treated as if the image is the current working space. When the image is saved, no profile will be embedded.

The check boxes allow you to define Photoshop default actions when a mismatch is found. If a box is not checked, Photoshop will execute the action selected for the particular color mode. When a box is checked, Photoshop will prompt you regarding what action it should take.

Conversion Options

Using the Engine drop-down menu, you can select the color engine (color management module) you want to use. We prefer Adobe (ACE) because it is probably better than ICM (Microsoft Windows) or ColorSync (Mac OS) and it will be the same on MAC and Windows.

As for Intent, you should choose Relative Colorimetric or Perceptual for photos (see "Color Space Mapping").

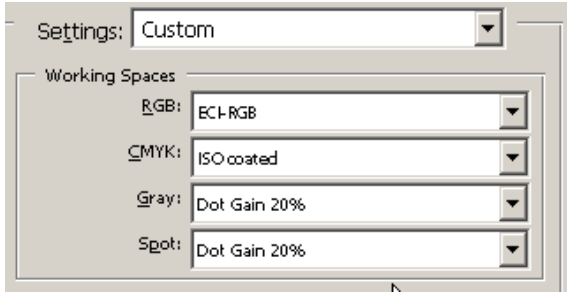
The Use Black Point Compensation option should always be on (checked). It helps when you are converting images from one profile to another by adapting the black point of the image to that of the destination space, thereby ensuring that the full tonal range of your destination (e.g., your printer) is used.

The Use Dither (8-bit/channel images) setting is effective only when converting 8-bit images from one color space to another. If the source color is not present in the destination space, Photoshop will try to simulate the source color using dithering. This may improve the color visual accuracy, but at the same time it will introduce some random noise (due to dithering) into your image. You should experiment on your own to find the setting you like.

Advanced Controls

Leave these settings at their defaults, as shown in figure 3-16.

Note: We ignore settings for CMYK and Gray here as we only cover RGB color setup in our workflow. If you live in Europe, your CMYK setting should either be *Euroscale Coated* or *ISO Coated*. If you are mainly preparing your images for prepress, use ECI-RGB as your default RGB color space, in which case your settings might look like this:



◀ *Figure 3-17: Recommended working spaces for prepress work in Europe*

Photoshop is not particularly intuitive when it comes to finding the monitor profile in use. So use this method to find out which monitor profile is currently active:

Windows: Right-click on some free space of your desktop. Select Properties. A Display Properties dialog box will pop up. Select the Settings tag and click button Advanced. Select tab Color Management. This will show a dialog box with all monitor profiles installed. The profile currently active is highlighted (see figure 3.16).
Here you may add further monitor profiles, delete installed ones and make another of the existing profiles your default monitor profile (you may have to restart RawShooter or Photoshop to have this change become known to them).

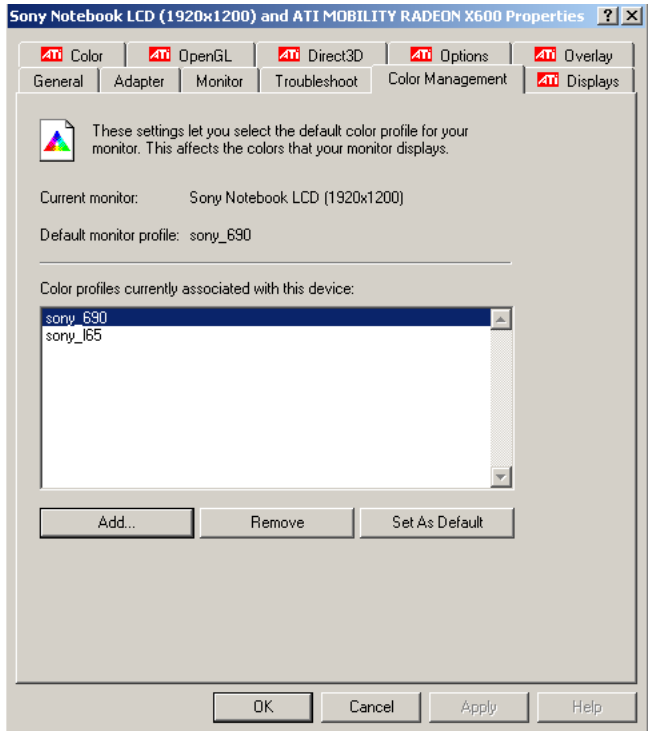
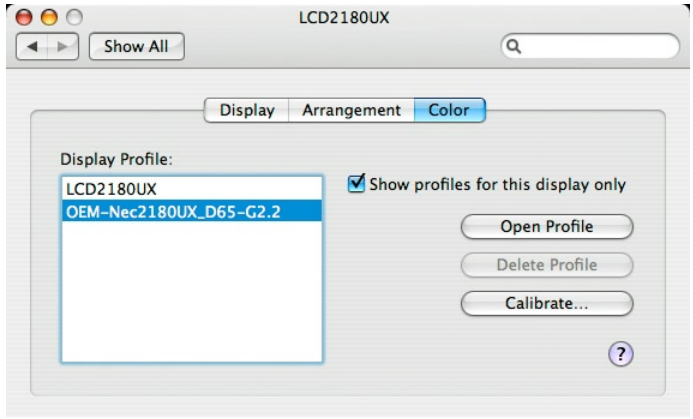


Figure 3-18: Finding the System Monitor Profile

If you are running Windows XP and have MS Color Control Panel installed (see [32]), you may also use *WinColor*, go to tab Devices and select *Displays* to see the profile, associated with your display.

Mac OS X: Call up System Preferences (you may find in your dock). Select Displays and activate tab Color. The dialog will list all monitor profiles installed and highlight the one currently active (see figure 3–19).



◀ *Figure 3-19: Current monitor profile in Mac OS X*

Note: Photoshop and most modern color-managed applications get their monitor profiles from the OS system settings.

3.6 Profiles for your printer

Having setup your CMS settings in Photoshop and calibrated and profiled your monitor, it's time to think about profiling your printers. There is, however, bad news: You must do it for each combination of printer+printer-/quality-settings+paper+ink-set. Let us assume we deal with just one printer – e.g. an Epson R2400 – and only use standard Epson inks for that printer. In this case we still have a separate ICC profile for each type of paper any for each quality or resolution setting of the printer. If you want to use glossy, as well as, semigloss and matte, we will need three different profiles, as each paper has a different gamut. Even if you want to use two different types of matte paper – e.g. 'Epson Archival Matte' as well as 'Hahnemuehle PhotoRag', you will need two different profiles.

But don't be frightened. There are several ways to deal with this – various ways to get a profile for your printer+ink+paper set:

1. **The profile may be part of your printer kit or may be downloaded from the web site of the printer maker**.
   These profiles will only cover the original maker's inks and some papers the printer maker sells. These are 'canned profiles' (also called 'generic profiles') that do not take into account individual derivations of your specific printer, yet may be a good start – depending upon the maker, the printer and the variations of the printer line. For recent printers of good quality (e.g. the Epson

R2400 or the HP Designjet 30/130) will give up to 95% of the maximum quality a customer profile could provide.

2. When using a third party paper, the paper maker may provide profiles for his papers and some well known fine art printers. Many paper makers, for example, provide generic profiles for the Epson P2100/2200 using Epson Ultrachrome inks and their papers (e.g. Hahnemuehle [38], Moab [39] or Tetanal [40]). If a new printer hits the market, it usually takes a few month, until the profiles for the new printer are uploaded to their internet site.

3. Some suppliers of third party inks provide generic profiles for their inks, profiled with often-used papers for some well established printers. For example Lyson [43] offers profiles for several Epson and HP printers for their (different ones) inks and their papers. You should also have a look at the home page of Bill Atkins [79] and his high quality profile effort.

4. There are several companies out there, that sell profiles for different printers and inks. Digital Domain, Inc [31]) is one example. There are several services that produce a special profile for you. The general scheme is this:

    1. You download a print target from the internet site of the service.
    2. You print the target using your specific printer, ink and paper (and other printer settings), and send the print to the service by snail mail.
    3. The service will measure your target print, generate the profile and send it to you by e-mail.
    4. You install the profile.

    The cost of this service varies a bit but should be from 30–100 $ US per profile, often lower if you order several profiles.

    This is definitely not a bad choice for customer profiles. It avoids the cost of expensive printer profiling equipment (software + hardware) plus profiling is done by experienced personnel. Some companies restrict their services to specific printers or makers. You will find a list of profile services in Appendix C.

6. **Build your own customer profile**.
This is the way we describe next.

Profiling your printer

Profiling a printer follows a basic scheme:

1. You select an appropriate target with well-known color patches and print that target on the printer to be profiled. When printing use the paper you intend to use, as well as, the ink set.
   You should use the same printer driver settings concerning print resolution, paper-type-choice and other setting values that you will use later on. It is strongly recommended, that you save these settings using a descriptive name (most printer drivers allow doing that). Avoid any color correcting settings at this point. Also, avoid any further color correction from the application you print from (e. g. Photoshop).
2. Let the print dry – at least one hour, better for 24 hours.
3. Now the colors of the print must be measured (there are several ways to do it) and profiling software will calculate the resulting ICC printer profile. Usually, it installs the profile immediately. Otherwise, you have to install it – using a way that is appropriate for your operating system (see section 3.7).

There are several ways to measure the colors of your target print:

A) Use a photo-spectrometer
   This is the most accurate way to do this job, but as the costs of a good photo-spectrometer is about 800–1000 $ US, it requires the most expensive equipment. Eye-One Photo (or Eye-One Proof) by Gretag Macbeth or PULSE ColorElite by x.rite are printer profiling suites we can recommend.

B) Use a dedicated patch-reader (a small, dedicated scanner) to read the patches of the target print.
   The patch-reader (e. g. as part of the *PrintFIX* kit by Color Vision [28]) is much cheaper than a spectrophotometer, but not as precise as the former (according to our experience, it is the least precise method of A-D).

C) Use a standard flatbed scanner for acquiring the patch values. As many user have a flatbed scanner, this is probably the cheapest way to do the scanning. The accuracy of the method depends very much on the (color) quality of the scanner. The scanner should profiled. Some profiling packages (e. g. Monaco-

EZcolor) for this reason scan a scanner target together with the printed target and (internally) do the profiling of the scanner first, and based on this 'profile-enabled scanner,' interpret the color values of the patches of the printed target.
This is a rather inexpensive and easy way for measuring the printed target, but for several reasons is less accurate than version A. Its accuracy should be about the same as good generic printer profiles and may be a cheap source of profiles, if using a third party ink set or paper, where no generic profile is available.

D) You may send your printed target image to a profiling service. In this case, you should use the target the service provides on their internet site and should accurately follow the instructions given there.
The accuracy of theses profiles should be as good as version A – maybe even be better, as the service personal probably have more experience than you do. The processing usually takes about 2–3 days plus the time it takes, to send the print via snail-mail. The costs per profile is about 40–80 $ US.

Printer profiling using Eye-One Photo

Eye-One-Photo is a profiling kit by Gretag Macbeth that consists of the software Eye-One Match (EOM), a photo-spectrometer Eye-One Pro, a scanner target (reflective) and a Mini-ColorChecker. It may be used to profile displays, scanners, printers and cameras and costs about 1.500 $ US and runs on Windows, as well as, Mac OS X. For profiling a printer, use the follow steps:

1. Launch Eye-One Match (EOM) and select the printer for profiling (see figure 3.17).

2. Select the type of target you want to print (figure 3-21).
EOM offers 3 types – a very simple one (i1 Easy RGB 1.x.txt), the standard target with 288 patches (i1 RGB 1.x.txt, which we recommend for inkjet printers) and a TC9.18 target for best quality (i1 RGB 1.5.txt). The TC9.18 target should only be used if you use a device that scans the printed patches automacially (is has many, many patches). If you profile a PostScript printer, your choices may be reduced to just 1 or 2 targets. For inkjets we recommend RGB 1.x.txt.
Now click Print to print the target.

Eye-One Match
Eye-One Match 3
Select the device you wish to profile
Help
Printers
This is the online help! It will guide you through every step of the profiling process.
Choose the device you wish to profile from the options on the left. Browse through the help to learn more about the different options.
Select your profiling mode and click the right arrow.

Figure 3–20: Eye-One match with ›Printer‹ selected for profiling

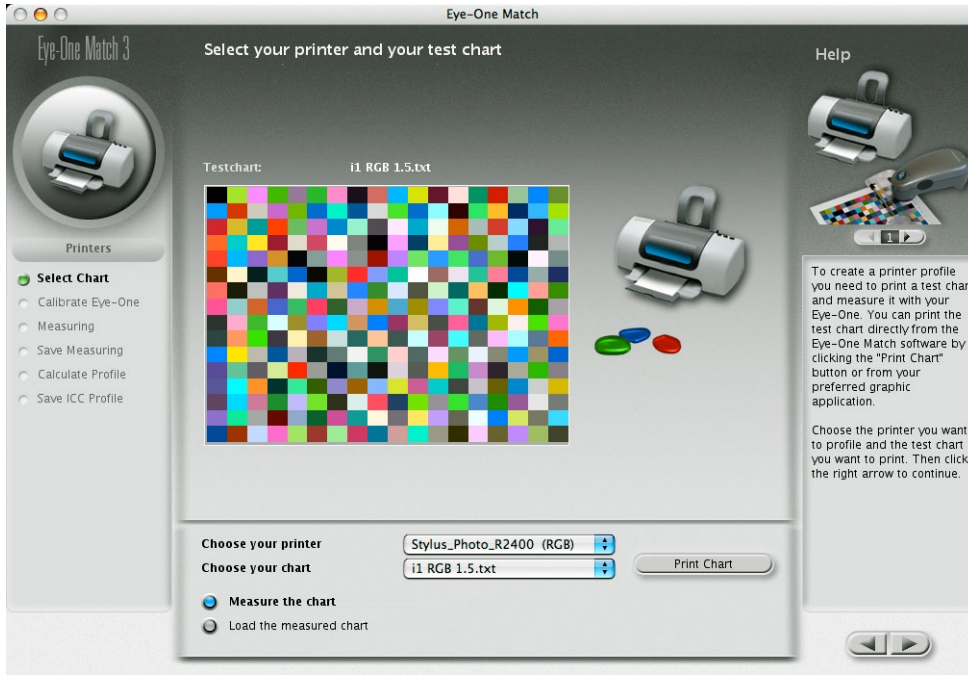

Eye-One Match
Eye-One Match 3
Select your printer and your test chart
Help
Testchart:
i1 RGB 1.5.txt
Printers
Select Chart
Calibrate Eye-One
Measuring
Save Measuring
Calculate Profile
Save ICC Profile
To create a printer profile you need to print a test chart and measure it with your Eye-One. You can print the test chart directly from the Eye-One Match software by clicking the "Print Chart" button or from your preferred graphic application.
Choose the printer you want to profile and the test chart you want to print. Then click the right arrow to continue.
Choose your printer
Stylus_Photo_R2400 (RGB)
Choose your chart
i1 RGB 1.5.txt
Print Chart
Measure the chart
Load the measured chart

Figure 3–21: Select the printer to profile and the target type

3. The print dialog of the operating system will display and should already be configured correctly. However, check that all driver color management is disabled and that all other driver settings are appropriately set for your target:
   A) correct paper type is selected
   B) print-resolution or quality settings are those you intend to use later on with that paper
   C) all other settings (e. g. ink-set, ink-density and so on) are set to those values you intend to use your profile for.

   This setup is dependant on your operating system, your printer (and printer driver) and may even depend on optional components installed or paper and ink-set used.
   When everything is set correctly (it may well be worth writing down, as well as, saving these settings for later use), click on Print.

4. Let the print dry for at least 1 hour. We prefer to wait for about a day before we proceed (finishing EOM first).

5. Restart Eye-One-Match; again select the printer for profiling and the target type used before. Activate the option Measure the chart and click .

6. EOM will ask you to calibrate your spectrometer by placing it on its profiling base. Press the calibration button at the site of the spectrometer. When EOM informs you that the calibration was successful, continue with .

7. Select strip-mode for measuring. Put your target print on your desktop and put a white paper underneath (if your paper is not reasonably opaque) to prevent the color of your desktop from distorting the colors of the patches. Use the transparent plastic ruler to guide the spectrometer along the patches as shown in figure 3-22.

   Now scan line by line, release the button of the spectrometer at the end of your sweep. OEM will indicate if the measurement sequence for the row was not OK. In that case, repeat the last sweep. Repeat this step for each row of patches. Click when all rows are scanned.

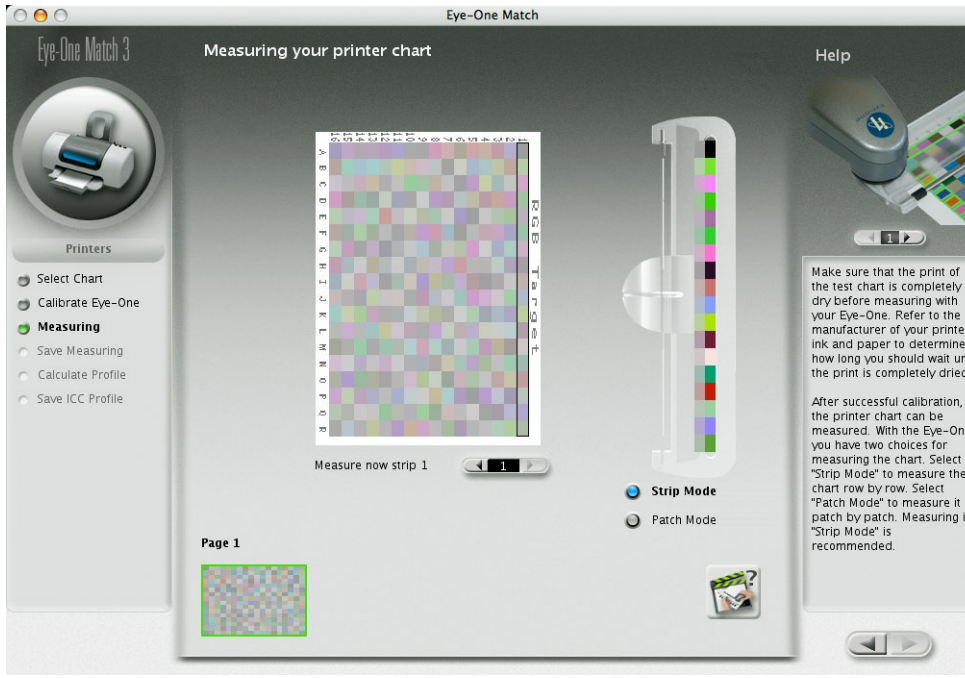

Eye-One Match
Eye-One Match 3
Measuring your printer chart
Help
Printers
Select Chart
Calibrate Eye-One
Measuring
Save Measuring
Calculate Profile
Save ICC Profile
Measure now strip 1
Strip Mode
Patch Mode
Page 1
Make sure that the print of the test chart is completely dry before measuring with your Eye-One. Refer to the manufacturer of your printer, ink and paper to determine how long you should wait until the print is completely dried.
After successful calibration, the printer chart can be measured. With the Eye-One you have two choices for measuring the chart. Select "Strip Mode" to measure the chart row by row. Select "Patch Mode" to measure it patch by patch. Measuring in "Strip Mode" is recommended.

Figure 3-22: Select the printer to profile and the target type

8. You may save the measurements. Continue with .
9. Now OEM will automatically calculate the printer profile and ask for a profile name when finished. Use a descriptive name which includes the printer name, the paper used and, optionally, special settings used. Clicking Save As will save the new profile and install it.

Please keep in mind, that this profile is only valid for the specific printer, the paper used for profiling, the ink set and the specific driver settings used. If any of these parameters change, you should do a new profiling. This may happen, when an ink supplier changes its ink recipe, which happens from time to time, (without informing the customer). So if your prints do not look as expected (after replacing ink), profile again.

You may use the same printer profile for Mac OS as well as for Windows – provided the drivers work the same and offer the same settings, which should be true if you use the original manufacturer drivers of companies like HP, Canon or Epson. With third party drivers (**e. g. with Linux or Unix) or** RIPs, you should profile again.

3.7 Installing and uninstalling profiles

When using profiling software, that software, in most cases automatically installs freshly generated profiles. If you download profiles, you may be lucky getting executable files that also install the profiles. In some cases however, you will have to do the installing manually. Here is how it is done:

Windows With Windows, profiles use either the file name extension '.icm' or '.icc' (both types may be used). Right-click at the profile file. A popup-menu will appear. Select Install Profile and Windows will install the profile for you. Here is a list, where the profiles will go:

Windows XP	c:\windows\system32\spool\drivers\color\
Window 2K	c:\winnt\system32\spool\drivers\color\
Windows 95/Me	c:\windows\system\color\
Window NT	c:\windows\system32\color\

You may (and on demand should) use the same method to un-install the profile (this time selecting Uninstall Profile).

Avoid keeping too many profiles. There are reports, that this practice may lead to problems with older Windows versions. For this reason un-install those profiles not needed (do keep a copy somewhere).

For Windows XP, there is a nice little Microsoft utility called *Color Control Panel* or *WinColor* which you may download from [24]. It is made to facilitate color management administration for Windows XP. It allows installing and uninstalling ICC profiles. The utility also allows displaying the color gamut of color space or profile and to compare the gamuts of two color spaces.

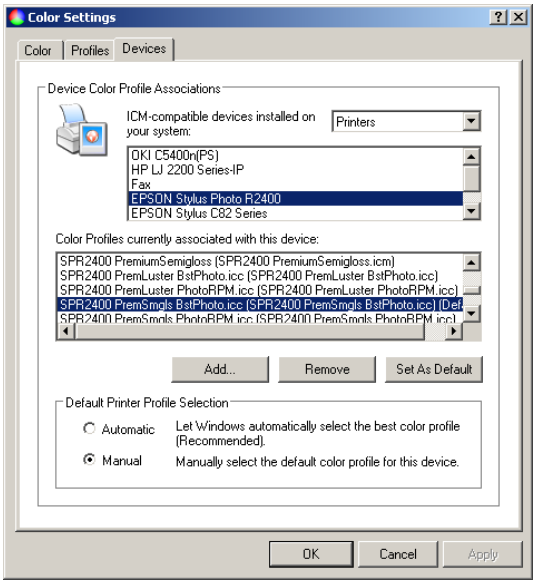


Figure 3-23: Color Control Panel for Win XP

Mac OS X With Mac OS, profiles use the file name extension '.icc', however, you may use Windows-profiles with an extension of '.icm' ,as well. Simply move or copy the profile to one (or several) locations given below:

Mac OS X	System/Library/ColorSync/Profiles/	[1]
	~user//Library/ColorSync/Profiles/	[2]
	Library/ColorSync/Profiles/	[3]
Mac OS 9	System Folder/ColorSnyc Profile/	

[1] These profiles are accessible to all users of the system, however you need to have administrator right to set, add or delete these profiles.

[2] These profiles are accessible only to the specific user and may be added or delete by the user.

[3] These profiles are those managed by MAC OS X and should be left alone.

Adobe applications use an additional location: *Library/Application Support/Adobe/Color/Profiles/* for some profiles. This location is for general use of Adobe applications and should not be used for device-specific profiles but only for new profiles for working spaces (e. g. if you want to add ECI-RGB as a general work space).

To uninstall a profile, simply delete it or move it to another location.

3.8 Finding the printers black point and white point

There is another piece of work you should do for a printer (printer/ink-set/paper/setting-combination), which is to print a white and black ramp to find out where your printer starts to differentiate tonal values. You will need this when optimizing an image for printing to a specific printer.

Print the B & W-Ramp (you may find a version at [19]) using your standard printing method and using your printer profile, selected in Photoshop (see chapter 5.3, page 5-6 for this) for this). Let the print dry thoroughly. Inspect the print to find out at what black and what white values you can differentiate in the black/grey patch field from

the enclosed black area and from the previous patch field. Use a bright white light source for inspection (preferable a D50 light source or diffuse day light) Write down this value. Now do the same for the white or almost white patches.

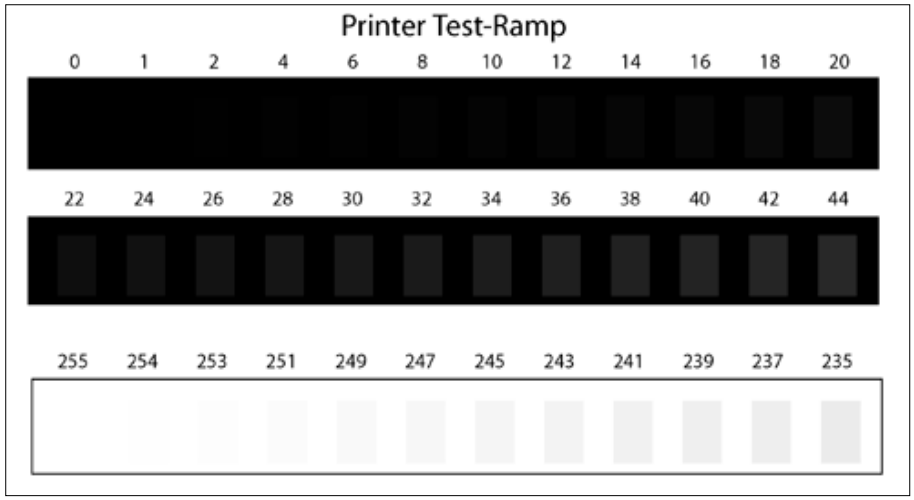


Figure 3-24: Image to find your printers black- and white-point

Don't become frustrated if your printer shows a long black ramp. Especially when printing to a laser printer (usually not adequate for fine-art-printing), the undistinguished black ramp will probably go up to about 40–44 and the white ramp down to 251. With a good fine art printer, however, those values should be much tighter (about 252–253 for white and 10–20 for black). Remember, you have to repeat this test for each type of paper used.

These are the values to which you should restrict your tonal values using Levels in Photoshop when preparing your image for printing (see figure 3.22).

Don't use original images, but only a copy made for printing – or use adjustment layers. This might look like reducing the tonality of an image, but as you see in the print of the B&W-ramp, all pixel values beyond the black-point will be printed with the darkest black the printer can produce and will not be distinguishable from black.

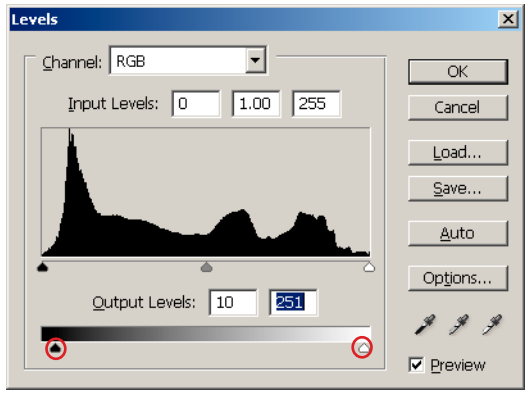


Figure 3-25:
Restrict your tonal values to the white point and black point of your printer.

All pixel values lighter than this white point will not be distinguishable from the white of the paper.

With some pictures, however, you may not want differentiated structures in your shadows which may even show some noise. Have them quite dark or black. In this case, use a lower value for your black point.

If you intend to use your image for a publication as part of a DTP project, and your image shows much white (or almost white) at the borders, it is often better to increase the white point a bit more into a light grey so that the white of an image will be set slightly apart from the white of the paper or the display.

3.9 Sanity-check

After profiling, be it monitor or printer, some sanity check should be done. There are some good images available on the Internet, that include different colors, grayscale ramps and so called *natural colors* or *memory colors* such as skin and face colors that are critical in an image. You may find the image of figure 3-26 at Bill **Atkinsons home** page [34]. Use one of those images to verify your profile and settings. If the displayed image on your monitor is off or the print on your printer using your profile is off, search for the source of the problem. With the monitor, you have to redo calibration and profiling. With a print make sure you did not color-manage twice – **e.g. in** Photoshop **and** again in your printer driver.

You may find some more useful images and test targets at Hutcheson Consulting [77].

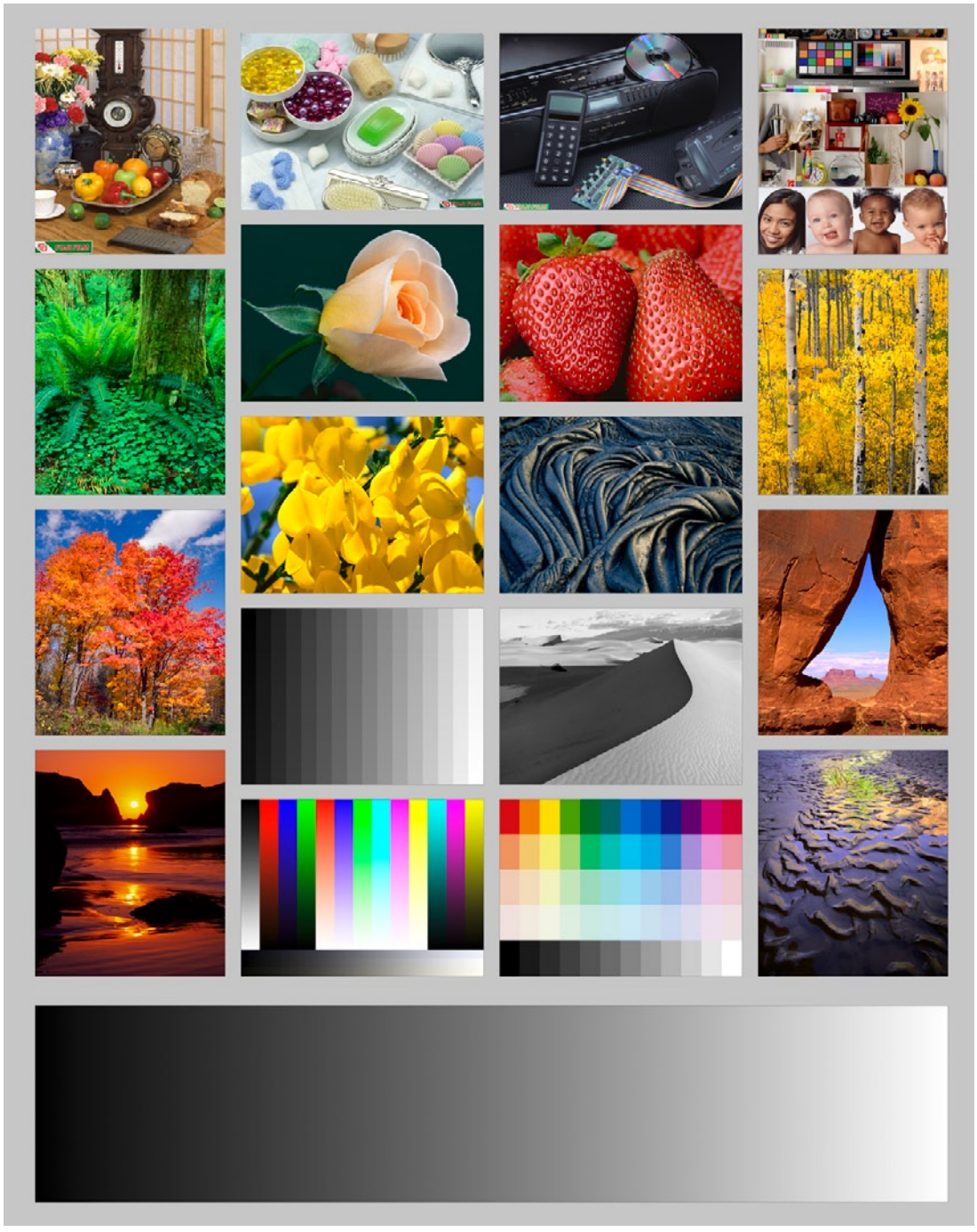


Figure 3-26: Image for your sanity check of your monitor profile or your printer profile and printer settings (www.jirvana.com/resources/printing/bills_lab_test_image.zip, designed by Bill Atkinson)

3.10 Soft-proofing and gamut warning

As said before, a printer may not be able to reproduce all the colors of an image truthfully – the printer may have a smaller gamut than the gamut of the image. All color management can do is to take the printer as close as possible to the impression of the digital image. Before printing, it is often useful to see on your monitor what a printed image will look like – to simulate the print on your monitor. This technique, supported by Adobe Photoshop as well as InDesign, Illustrator, Acrobat and some other (non Adobe) applications is called *Soft-proofing*. For such proofing, the image is implicitly converted to the printers color space (you need the printers ICC profile for this) and the result is displayed on the monitor. This is useful with inkjets to avoid costly and perhaps disappointing prints. It is still more important with commercial print runs, like offset prints, as those runs are much more expensive (imagine a print run of 2,000 books showing inadequate photos). To achieve an optimal (faithful) proofing, your proofing device – in this case, your monitor – should be able to reproduce all colors that the proofed device (the printer) may reproduce. As we saw in chapter 1, this may not hold completely true if you soft-proof modern photo inkjet printers on your monitor, since modern photo inkjet printers have a gamut exceeding that of most current monitors (at least in some color areas).

To setup soft-proofing in Photoshop call up View ▸ Proof Setup ▸ Custom. The dialog box of figure 3-27 will come up:

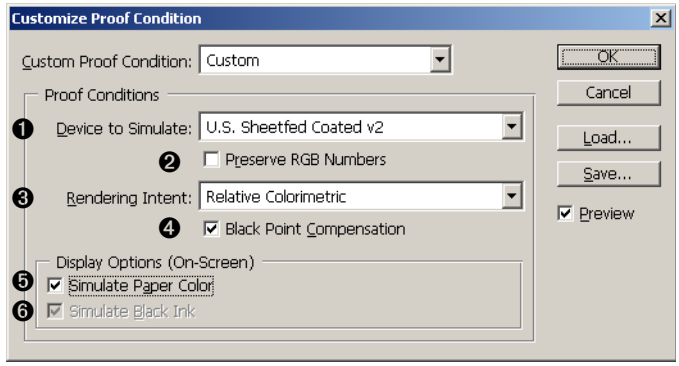


Figure 3-27: Proof setup in Photoshop

Select the profile of the printer you want to simulate with your proof ①. As with standard printing, make sure you use the printer profile that reflects the printer (or printing technique in case of offset or rotogravure printing), the kind of paper used, the kind of inks used

and the proper printer settings. Leave Preserve RGB numbers ② **unchecked**! Select your rendering intent ③. As mentioned in section 3.2, page 3-14, select the rendering intent you will use later for printing or profile conversion. For photos, this should either be *Perceptive* or *Relative Colorimetric*.

You should activate Black Point Compensation ④ and Simulate Paper Color ⑤. The latter will also activate Simulate Black Ink ⑥.

If you want to do soft-proofing regularly, you should save these proofing-settings and give them a descriptive name (including the printer simulated as well as the paper and printer settings).

In order to activate soft-proof, select View ▸ Proof Colors (or just enter Ctrl-Y (Mac: ⌘-Y). Using Ctrl-Y you may toggle proofing on and off (in most cases, for image optimization, it should be off).

Gamut Warning

If you have setup your soft-proofing, you may also activate *Gamut Warning* (View ▸ Gamut Warning or ⇧-Ctrl-Y (Mac: ⇧-⌘-Y). When Gamut Warning is active, Photoshop will mark all areas of your image that use colors that are 'out of gamut of your target color space'. Default marking color is grey. As grey is a color easily overlooked, we recommend selecting a different warning color – e.g. an aggressive magenta, which rarely occurs in photographic images.

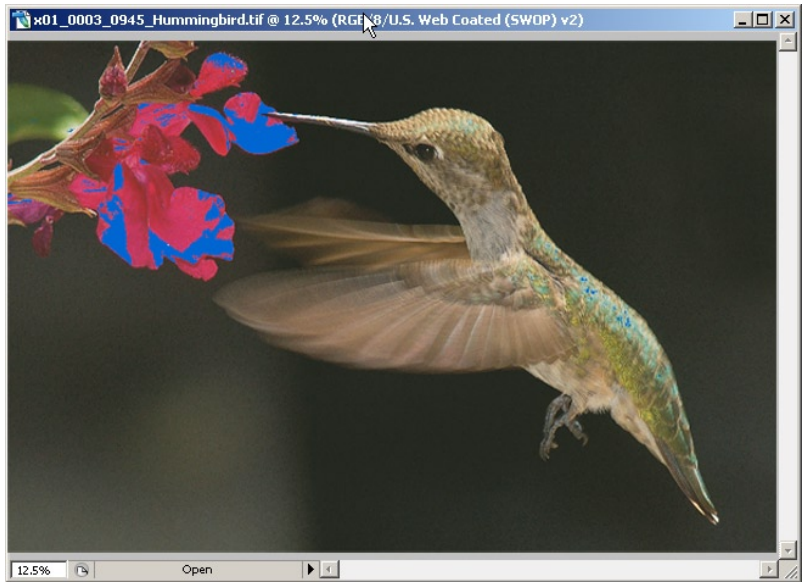


Figure 3-28: Image displayed with Gamut warning active. ■ is used as warning color and 'U.S. Web Coated (SWAP) V2' as destination profile.

To set a new gamut warning color, select Edit ▸ Preferences ▸ Transparency & Gamut. A click on the Color field will display the color picker.

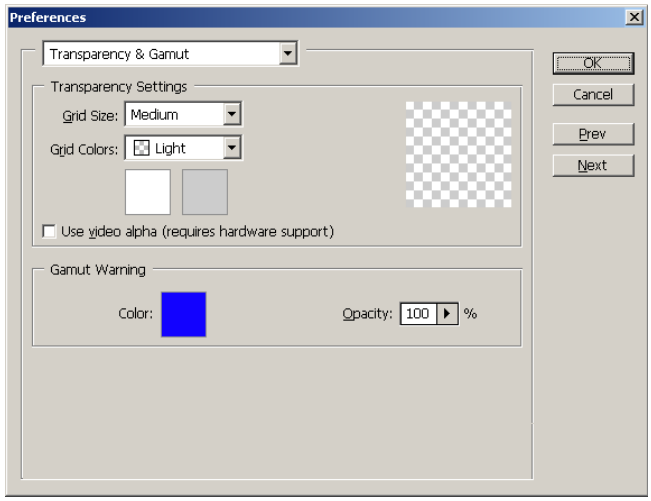


Figure 3-29: setup for the color for Gamut Warning in Photoshop

If you did not do a custom proof setup in Photoshop and activate Gamut Warning or Proof Colors, the CMYK setting of your Working Spaces setting is used as a default (see section 3.5).

Again, you may toggle Gamut Warning on and off using either ⇧-Ctrl-Y (Mac: ⇧-⌘-Y) or going via the View menu.

What is Gamut Warning really good for? First of all, you will get an impression of which colors in your image may not be reproduced truthfully but will have to be remapped to different colors (usually mapping highly saturated colors to less saturated ones). It may also help to modify these colors (colored areas of the image) so that they fit well into the destination color space (usually the printer's gamut). Decreasing their saturation or otherwise tuning these colors may be done in a more controlled way than is done by automatic gamut mapping which only may be controlled by the selection of the rendering intent (see section 3.2, page 3-14).

Even if Gamut Warning is not active, you will get a warning in the Color Picker dialog when you pick a color 'out of gamut' of your target device (either selected explicitly by a proof setup or by default by your Photoshop Color Settings for CMYK). If you pick a color that is out of gamut, a triangle ⚠ will show up beside the selected color (see figure 3-30, ①). If you click into the field ②, the selected color

will be replaced by a color as close as possible and fit into the destination color space.

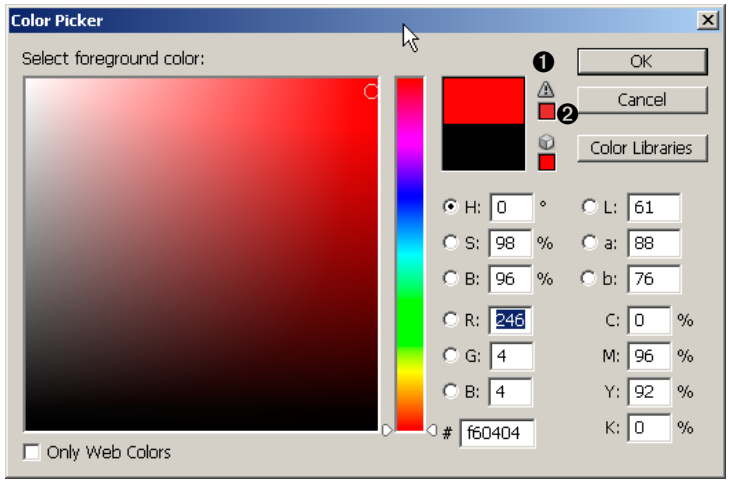


Figure 3-30: Gamut Warning in Color Picker

Understanding the HSB/HSL model

The HSB (***H**ue, **S**aturation and **B**rightness*) or HSL (***H**ue, **S**aturation and **L**ightness*) are not explicitly supported models by Photoshop but is used in quite a few places like the Photoshop color picker (see figure 3-30) or the Hue/Saturation tool. Here, the hue is given using an angle from 0° to 360°. 0° (as well as 360°) corresponds to red, 90° to green, 180° to cyan and 210° to blue.

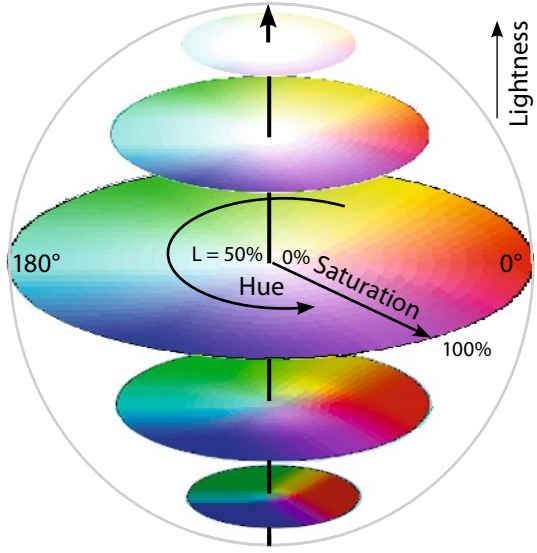


Figure 3-31: HSL/HSB color model

Saturation has a range from 0% (white) to 100 % while Brightness runs from 0% (black) to 100 % (white).

In some dialog boxes – those changed from the current saturation like the Hue/Saturation dialog – Saturation may also run from -100 to +100. The same is true for Lightness slider.

3.11 Metamerism and bronzing

There is an phenomenon called *metamerism*. The term is usually used when describing a problem that may occur using some inks in prints. Metamerism is the effect when colors look different under different lighting. It is very natural and well known to us. When there is almost no light, all cats look grey. When there is very low light, colors may look bleached out because too much light is reflected. Similarly, printed colors are absorbing part of the light spectrum hitting the paper and reflecting other parts. When the lighting changes, the color spectrum and the intensity of the different wavelength of the incoming light changes. This will lead to a different pattern of absorbed and reflected light waves. An additional phenomenon constantly used in all printing techniques is that a certain color may be achieved (built up) by various combinations of primary colors (inks).

Under normal light, the metamerism effect may become a problem, when two colors built up of different primary colors create the same (or similar) color perception under one light (let's say a halogen-based lamp) but create a different color perception under another lighting (let's say tungsten lamps). The metamerism phenomenon may create a problem when two colors change their visual color distance with changed lighting. To achieve a sound basis for color judgment in practically any color management system, D50 (daylight at 5,000 Kelvin) is defined as the standard lighting for inspection of printed colors. Some printer profiling packages and some RIPs (e.g. ImagePrint by ColorByte Software as described at chapter 6.3 at page 6-12) allow compensation for a different lighting target.

The intensity of the metamerism with two colors may depend on the kind of inks used, the combination of primary inks the colors are built up with and the dithering method used by the printer driver or RIP. Some pigment inks are more prone to produce problematic metamerism. This was a problem with the second generation Epson UltraChrome inks (but was reduced by its third generation K3 inks). The effect may be reduced somewhat by different mixing of primary inks to achieve certain colors, and it may be reduced further by using different dithering patterns (This is why some RIPs reduced metamerism using second generation Epson UltraChrome inks, e.g. using the Epson P2100/P2200 printer line).

Bronzing is a phenomenon occurring with some inks – mostly black – due to their reflective properties. Under certain lighting conditions, correct inks – build up color samples – yet take on a slightly bronze appearance. On prints, this is usually disturbing and undesirable. Bronzing is an effect attributed to some Epson pigment inks of the first (e.g. with the Epson P2000 printers) and to a lesser extent of the second generation (Epson P2100/2200 printers). The inks formulation of the third generation of UltraChrome inks eliminated this problem almost completely.

When a print shows disturbing bronzing, this effect may often be reduced or eliminated by framing the print under glass.

Chapter 4

Fine Art Printing Workflow

Camera: Canon 1Ds Mk. II

So far, we have discussed printing techniques, papers, inks and practical printing, but there remains a large gap: How to prepare an image for printing. Of course, you may simply open a master image in Photoshop, call up the print dialog and leave the adaptation to Photoshop and the printer driver. This, however, may not lead to the best possible results. At this time, we want to describe our own workflow for printing which you may adapt to your own preferences and requirements.

4.1 Basic printing workflow

Printing workflow begins when you have converted a file from RAW or imported your camera JPEG or scanned image. Next, you edit your file – correct tilt and do any perspective corrections. Crop your image (if necessary). Corrections of lens deficiencies may also be necessary (e. g. correcting lens distortions, vignetting and chromatic aberrations). If there are dust patches, other blemishes or unwanted objects in your image, remove them now or as early as possible in your workflow. If necessary to remove them later, before you print, use the same techniques described in our other e-books DOP2000 [20] and DOP3002 [22]).

You have done some initial sharpening, but final sharpening should be left until the very end of optimization – or even left to your RIP when using one offers first class output specific sharpening.

Let us call the result of all this your 'first master' draft. Basic color corrections have been done already. The image is now 'correct', but may not be completely to your liking.

The next step is to optimize the image until it appears similar to what you had in mind when the picture was taken or scan was made. This often requires tonal optimizations including contrast enhancements and selective color correction. We deal with this in section 4.2 and section 4.3.

Note: Keep contrast more on the soft side as you can add contrast during fine tuning, but it is very hard to get soft gradations from harsh contrasty images.

Most of these corrections can be applied first globally and then both selectively and locally. The result is an image (and an image file), we would like to call our *master image* (we know, there are other usages of the phrase 'master image' in use).

It is at this point actual printing workflow begins (section 4.4). This implies that your image is pretty close to getting a good print, but you still need to fine tune the result. It is also assumed you are using a good printer profile. But a printing workflow is also about correcting imperfections in your profiles and/or printers.

4.2 Tuning tonality

To obtain correct tonality is key in every good print. There are no hard and fast rules as to what is good and not so good tonality. It very much depends upon what you wish to express.

Note: Take, for example, a photo of a foggy scene. On one hand, you can make the image so soft that it looks like a hazy mess, or you can turn up the contrast so much you lose all soft characteristics of fog.

It is important to remember that we are discussing the tonality you create on a print. No way can you produce the same high contrast on paper as can be seen on-screen. This also includes realizing that matte papers produce consistently lower contrast prints than the same image on semi-gloss or gloss papers.

Tonality includes:

- Brightness
- Contrast in
  - Midtones
  - Shadows
  - Highlights
- Smoothness

Unfortunately, all these elements are related and must be tuned in careful iterations.

As always, begin by adjusting the global tonality as best possible, and then continue working on local areas to improve tonality there. The core tools used to adjust tonality are Photoshop Levels and Curves.

Brightness

Brightness seems to be a basic property. But again, it always depends upon what you want to show in your print. Both very dark and very bright images, can be beautiful. Also important, is where you display your images. This is the reason you should try to judge images under controlled light – both for brightness and light spectrum (see Chapter 8: "Image Judgment").

First, let's take a look at the different tonality ranges of an image.

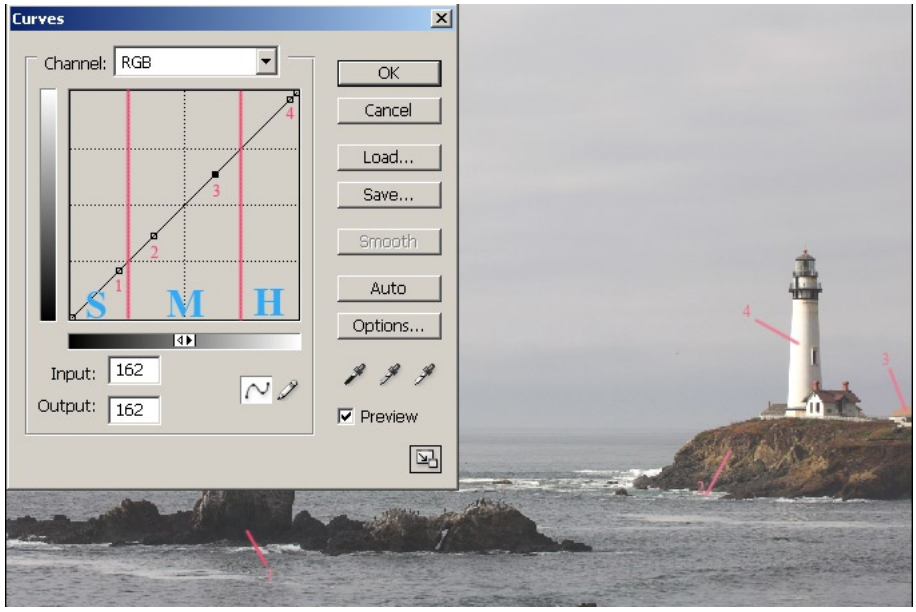


Figure 4-1: Tonality regions

We use the Curves tool (black on the left, white on the right). The standard grid setting displays 4 segments. Roughly, the first quarter makes up *shadows*; the next two *midtones;* and the last *highlights*. Three regions must be treated carefully but play a different role for the viewer.

- S = Shadow area
- M = Midtones
- H = Highlights

Midtones

The primary content of any image is in its midtones. You must be very careful to achieve good midtone contrast. Otherwise, you have a very flat image. We show the following test (figure 4-2) to demonstrate that you do not lose content in an image making the shadow range only black and highlights white.

In Figure 4-2, we cut-off all data in shadows and highlights and stretched the midtones over the full range from 0–255. As you can see, the entire content remains, but the image looks ugly and quite unrefined.

One might conclude that highlights and shadows are "the icing on the cake".

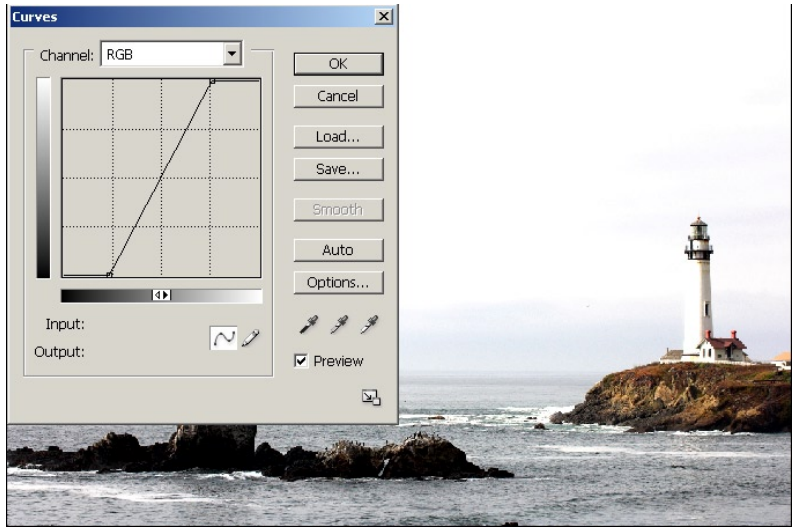


Figure 4-2: Showing only the midtones data

Without solid highlights and shadows you cannot create a quality print. Both shadows and highlights are, in general, the more important parts.

Shadows

Shadows can be open or close to black. There are cases where complete black is fine, as here:

Figure 4-3: Grass

A solid black background works here, because the photo has a strong graphic character, and background details would be distracting. The rocks in our lighthouse photo cannot be only black. You must balance open shadows with overall contrast. You will realize that opening up shadows lowers the overall impression of contrast.

There is an additional challenge in the shadow portion of digital images: Most noise is hidden in the shadows. This implies that you may find it necessary to remove noise when you open up shadows substantially (see later in this chapter).

Highlights

Highlights are largely a challenge during image capture. If you overexpose highlights, data is lost forever. If you underexpose too severely, you lose dynamic range and pictures tend to be noisy.

Correct highlights bring a proper sparkle to your images. If they are too strong, like in figure 4-4, all the smoothness and beauty of the photo disappears.

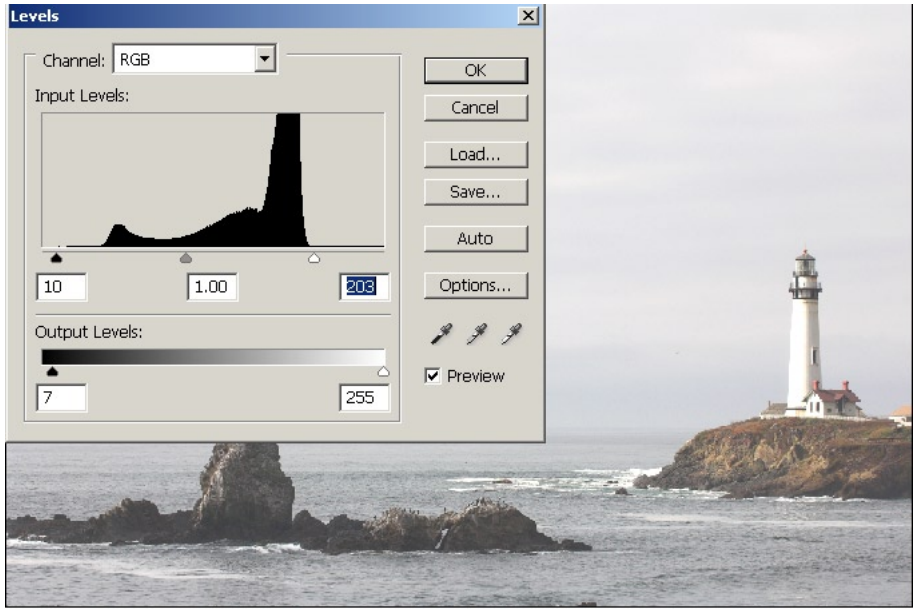


Figure 4-4: Overly strong and blown highlights

The other extreme is muddy highlights, like in figure 4-5.
The image looks dull and dark. We must find a balance between these two extremes. If your original photo resembles the first sample (blown highlights), there is little you can do to get a good, or even acceptable, print. The second example still permits getting a good print if we correct tonality and live with some level of noise.

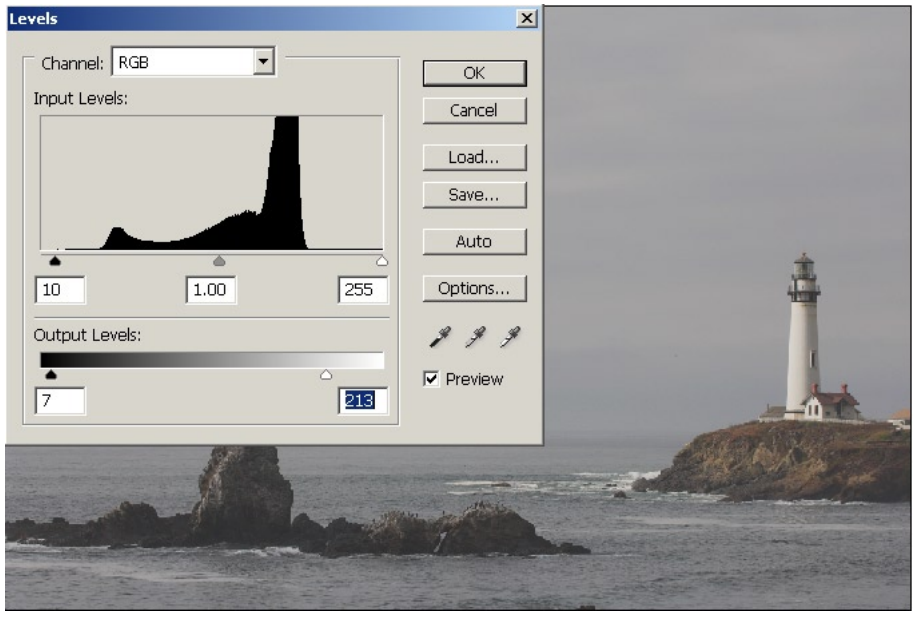


Figure 4-5: Muddy highlights

Contrast

The correct contrast is vital for any good print. With too little contrast, you end up with muddy, flat-looking prints, but with too much contrast, harsh tonality. There is no 'rule of thumb' here, as it depends on your images and what qualities you want them to depict.

Be aware that paper cannot reproduce the contrast you see on screen – same for brilliantly projected slides versus the same images on a print. Begin with slightly soft contrast, and tune the image for the balance you want.

Note: Comparing the same image with different contrast is quite tricky, as the more contrasty image nearly always grabs your attention. This does not at all mean that a higher contrast image is the better choice. Generally, it is good practice to view a photo at higher contrast to discover whether you are missing an opportunity to improve your image. If the higher contrast is created at the expense of too highly compressed highlights and/or dark blocked shadows, then it is likely time to pull it back a bit.

Global tonality tuning

The first step in tonality tuning is to set global tonality as closely as possible to the final result you intended. *Global* means that all pixels in an image are treated with the same transformation; that this operation does not depend on other pixels in context even if a user selects a certain area as a limit to this operation (we cover this later in this chapter in section "Local tonality tuning").

Tonality tuning using Photoshop 'Levels'

Levels is a major tool for tuning tonality. It is easiest to understand its function by looking at a sample image.

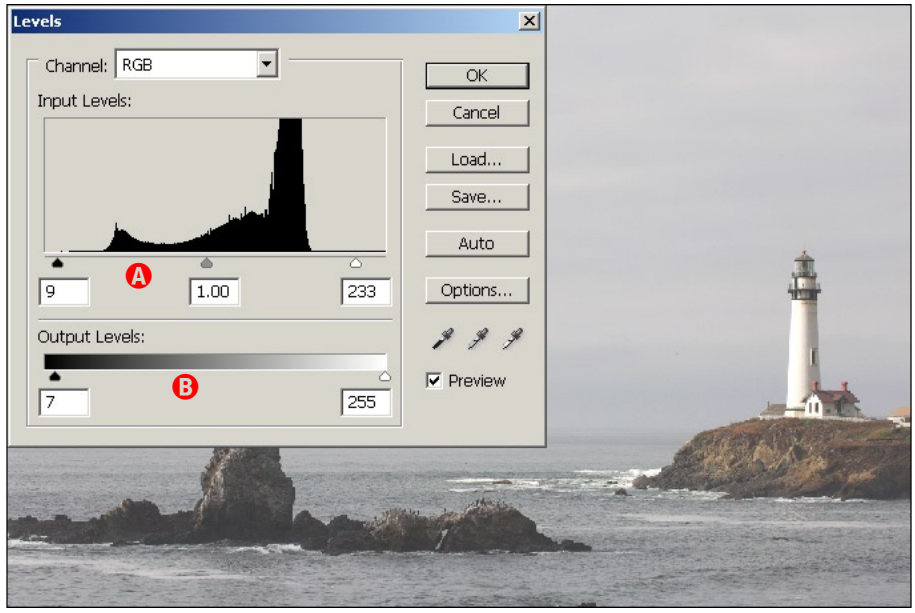


Figure 4-6: Levels in action (preview on)

We display the same image with preview 'on' (figure 4-6) and 'off' (figure 4-7). Levels in Photoshop have 5 sliders which are important to understand:

- Three for the Input Levels (see figure 4-6 Ⓐ) and
- Two for the Output Levels (see figure 4-6, Ⓑ)

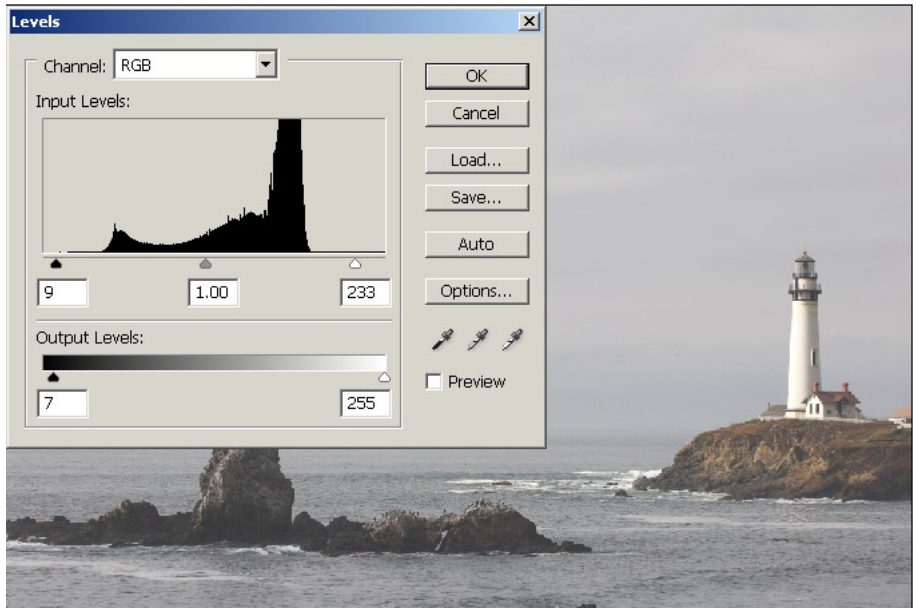
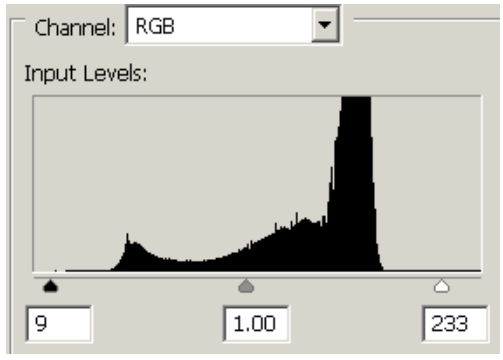


Figure 4-7: Levels in action (preview off)

Input Levels

Lets first have a look at the **Input Levels**.



We use Levels only in RGB mode. The histogram is some help in visualizing the distribution of different tones. It is not a good idea to correct by looking only at the histogram. We prefer to adjust Levels while viewing the full image.

There are three triangles, which become sliders, used to correct (from left to right):

- Black Point
- Gamma (brightness)
- White Point

With this lighthouse photo, we use the Black Point slider (▲)to achieve a bit more black in the shadows. We have to be very careful not to block the shadows too severely in the rocks. If we set the value to 9, all pixels having a value of 9 or less will have a value of zero after this operation. All other values are linearly transformed and receive some lower (darker) values. If we do not correct the white point, as well, the entire image becomes just a bit darker with additional contrast.

The Gamma (Brightness) slider ▲ remains at a default value 1.00.

As said earlier, setting the White Point slider △ can be a balancing act. You want a slight sparkle, while maintaining a smoothness, in the highlights. If we set the value to 233, for example, all pixels at 233 will be now become 255. All the other values are linearly transformed and will be set to some higher (brighter) values.

Output Levels

Figure 4-8: Output Levels

Output Levels becomes useful in a case where the printer (with its profile in use) cannot show a difference between lower black levels (0–*x*). Let's assume that the printer cannot show different black levels below 7. In such a case, we may push ▲ of *Output Levels* up to 7. This means, that the black values of zero are now transformed to 7, and all other values above that are linearly transformed. See chapter 3.8 page 3-35 for more on this.

Why do we say "may"? Because it very much depends upon what you desire in your print. Some images look perfectly fine with all black below, lets say 7, looking the same. We need to do scarcely any corrections for the output white point △, as most well-made profiles take care of that.

Note: When correcting tonality in B&W images, sometimes you can correct a bit more aggressively, gaining a higher contrast. Doing so can often help a B&W image.

As you see, Levels are a very useful tool in correcting tonality. Always correct by visually inspecting an image and not trusting the histo-

gram alone. On the other hand, try to avoid removing too much shadow detail, and always think twice before clipping off highlights.

We only perform Levels corrections using a new adjustment layer. Doing so, we can stack corrections and still fine-tune values later.

Tonality tuning using Curves

Curves are more complex and also more powerful than Levels. In principle, you can do everything in Curves you can do in Levels – while the reverse is not true.

Our first example shows how you may simulate Levels using Curves:

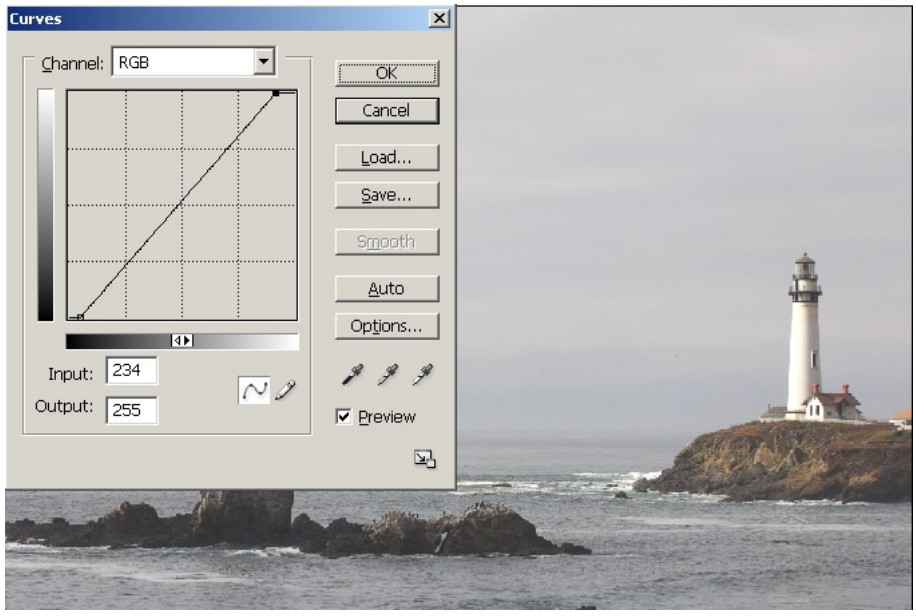


Figure 4-9: Linear transformation with Curves

Of course, in these cases, it would be advisable to use Levels. But a linear curve can provide a good starting point for more advanced curve corrections.

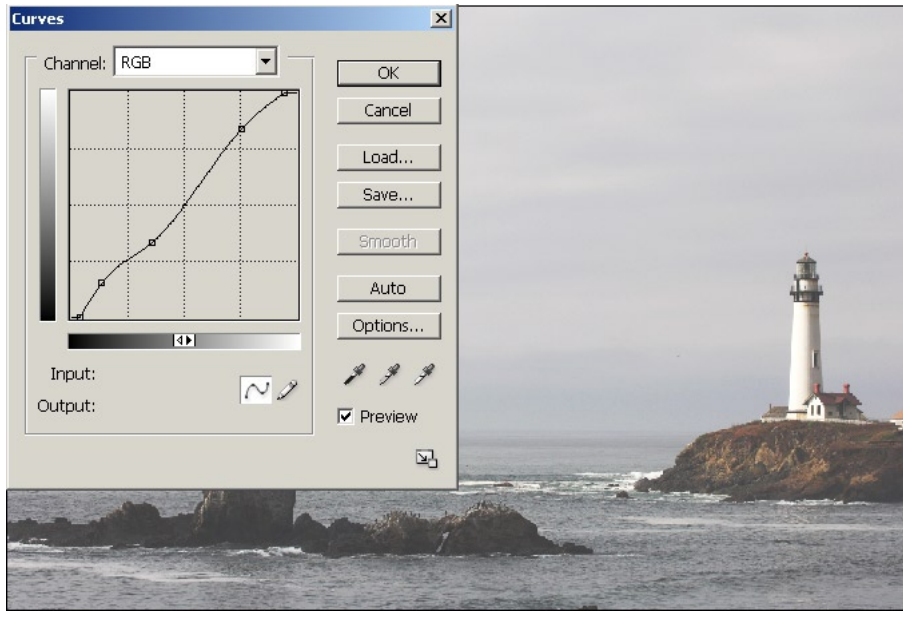


Figure 4-10: Some more advanced curves

Here (figure 4-1, page 4-4),, we start with the linear curve of figure 4-9 and tried to achieve the following:

- Slightly brighten the shadows (foreground rocks)
- Increase contrast in the midtones and highlights (S-Curve)

Be very cautious that no section of your curve becomes too flat or steep as the latter may result in posterization.

Some useful standard Curves shapes

For minor global **brightening/darkening** we use these curves:

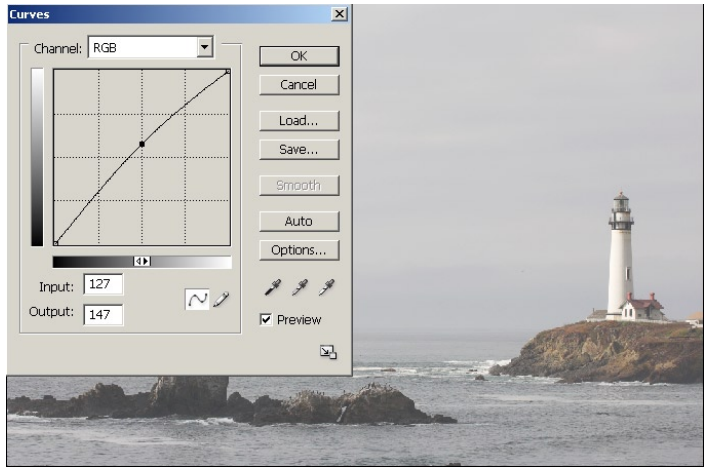


Figure 4-11: Brightening curve

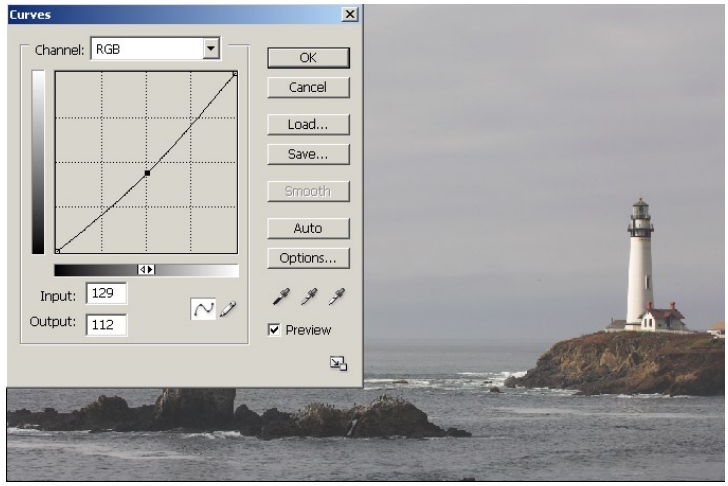


Figure 4-12: Darkening curve

Why do we use Curves here and not Levels? With Curves, we are able to tweak behavior much easier than with Levels, where we are unable to change the gamma curve used by Levels.

We use **S-curves** to enhance contrast:

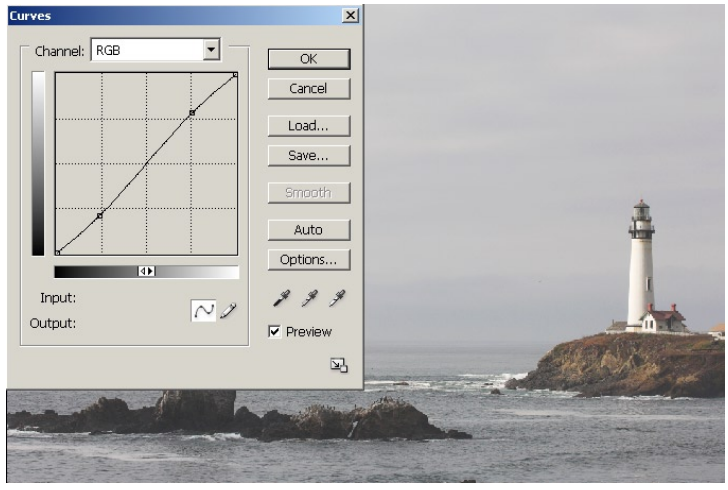


Figure 4-13: S-Curve to improve contrast

This curve looks like a shallow S-curve, but it has a strong effect on an image. In our view, a major down side of curves is that minor changes often have dramatic (and even negative) results.

What also happens, in this case, is that midtone contrast is nicely improved without compressing shadows and highlights too much. Especially in this image, shadows are very delicate, and we want to avoid this type of compression. We use Adjustment Layers for Curves adjustments, and fix some problems by changing the Advanced Blending Options:

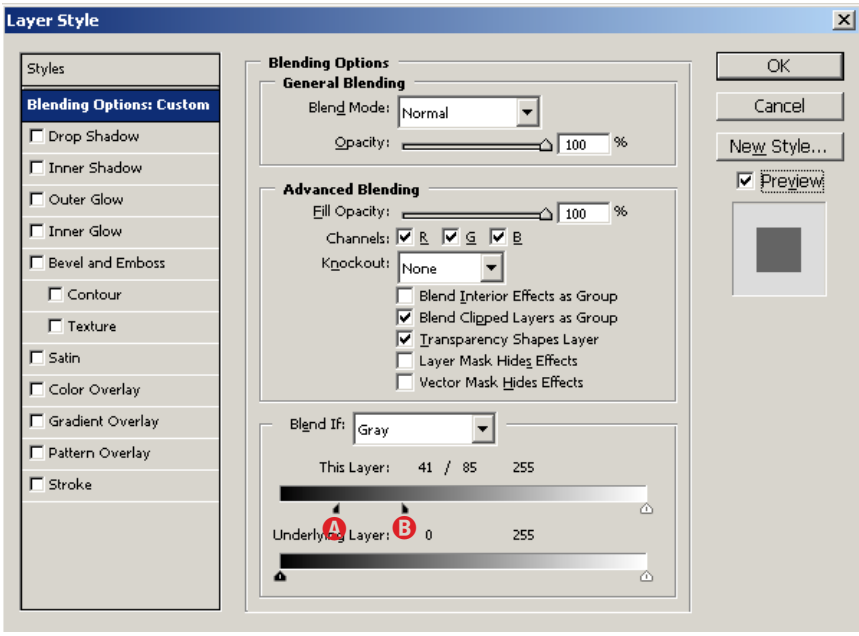


Figure 4-14: Advanced Blending settings to preserve the original shadows. Here, blending is controlled by slider Ⓐ and Ⓑ.

Alternatively, we use a different curve that restricts the S-curve entirely to midtones:

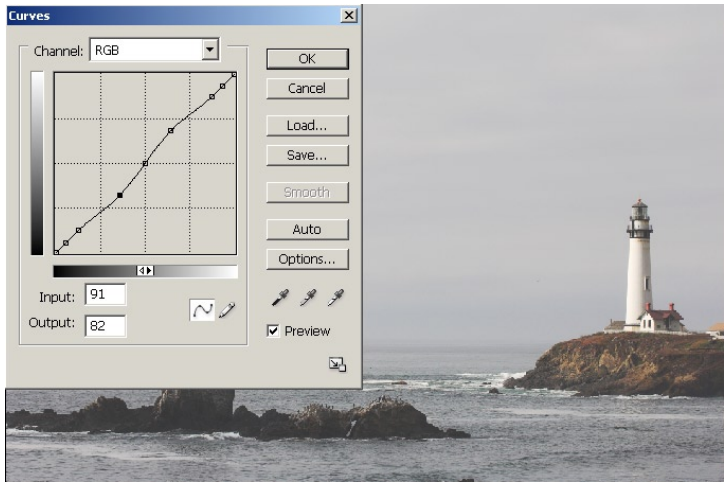


Figure 4-15: Midtones S-curve

In this case, we prefer the latter solution. Overall, the S-Curve can be extremely useful in many situations.

Local tonality tuning

We assume that, in most instances, you have done essential global tonality tuning before beginning your printing workflow. In fine tuning your prints, it is vital to understand how to perform local tonality corrections that only apply to parts of the image. Here are some major ways to improve local tonality:

- Adaptive shadow and/or highlight correction
- Corrections to selected areas using masks
- Corrections related to certain tonality ranges (shadows, midtones and highlights)
- Painting techniques (mainly dodge and burn)

Adaptive shadow and/or highlight correction

We talked a lot about shadows in the section on local tonality tuning. In fact, tools such as Levels and Curves understand shadows differently than we normally do. They consider a shadow as pixels with reduced brightness. Let's demonstrate what we mean with this example image:

Figure 4-16: Shadows and dark areas

This picture contains dark letters but also real shadows. From their pixel brightness, the black letters, although in the sun, may be as dark or even darker than the real shadows. Curves, as well as Levels would treat both the same way. That is not really what we intend when we plan to open up shadows a bit.

In situations like this, there exist more and more tools that work *adaptively;* they take into account the context in which the pixels reside and not merely a single pixel value alone. The best known tool currently is Photoshop's Shadow/Highlight tool. Below is a demonstration target to show the principles of how Shadow/Highlight works.

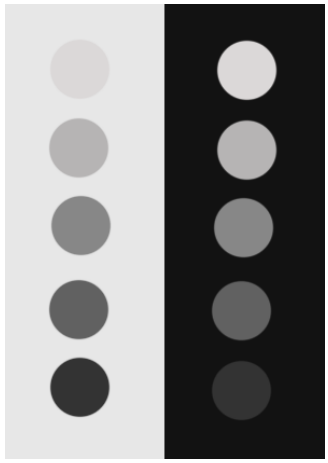


Figure 4-17:
Shadow/Highlight test chart

There are five incrementally darker dots in each column identical in both columns. It is well known that we perceive the same brightness differently, depending upon its context:

- Bright spots look brighter in a dark context
- Dark spots look darker in a bright context

This should illustrate that treating all pixels equally, as with Curves and Levels, is not helpful at all times. Why don't we see more of these adaptive tools today? Because they are:

- Computing intensive
- May have color-shift side effects
- Sometimes create issues at their edges (e.g. show halos – watch out for them)

Shadow recovery

This is the result when Shadow/Highlight is used to open up shadows:

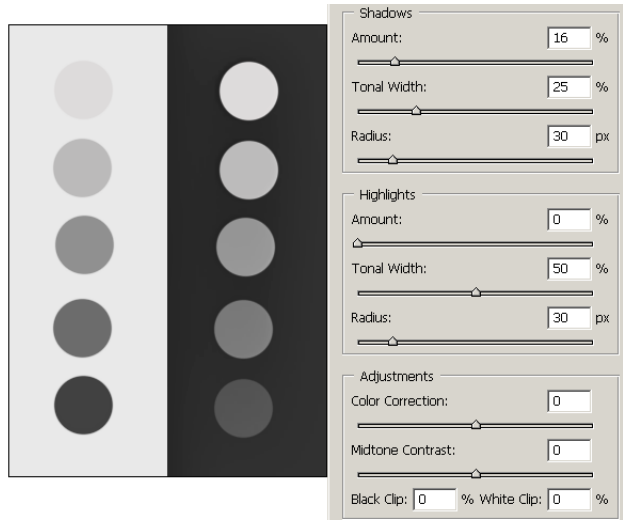


Figure 4-18: Shadow/Highlight used to open up the shadows

This we can observe:

- All spots in the bright area remain unchanged
- The dark background brightens up
- The three darker spots on the darker background changed brightness

Highlight recovery

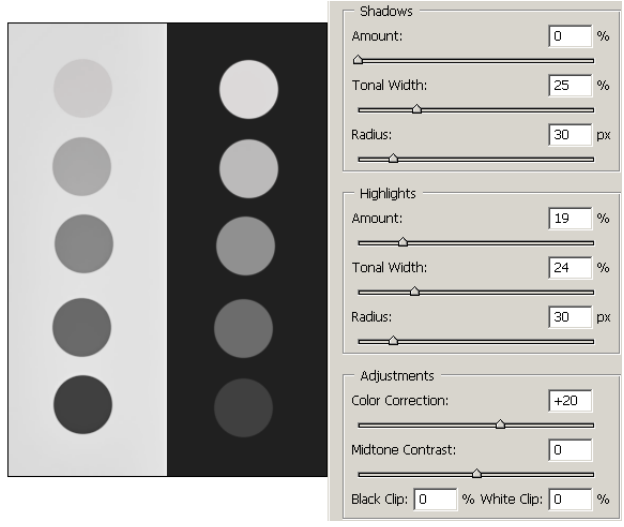


Figure 4-19: Shadow/Highlight used to tone down highlights

Now, here is what we can observe:

- All spots in the dark area remain unchanged
- The bright background darkens
- The four brighter spots on the brighter background change their brightness

True, you could accomplish the same thing with complex masking, but the main drawbacks would be:

- More complicated, involving much more work
- With real world images and fine details, masking can become more than merely a minor challenge

Corrections to selected areas using masks

This book cannot cover all techniques possible in using complex masks, and the fact is, we rarely use them anyway. But here is a technique that often works pretty well.

Figure 4-20: Start photo

We wish to make the shadows on this dune shot a bit brighter. It looks kind of OK on the screen, but when printed, we found it a bit too dark.

Figure 4-21: Select the shadow area with the lasso tool.

Figure 4-22: Selection shown in Quick Mask mode

We switched over to the Quick Mask mode (use the key [Q]) and could see that mask edges are too difficult to make a clean selection. We then feathered the selection (with values between 25–150 depending on the image and the selected area):

Figure 4-23: Selection feathered at 50

Figure 4-24: Same selection shown in Quick Mask mode

We needed to tune the selection a bit at the upper dune shadow edge. Finally, we used a Curves Adjustment Layer with this selection as a layer mask to brighten up the shadow:

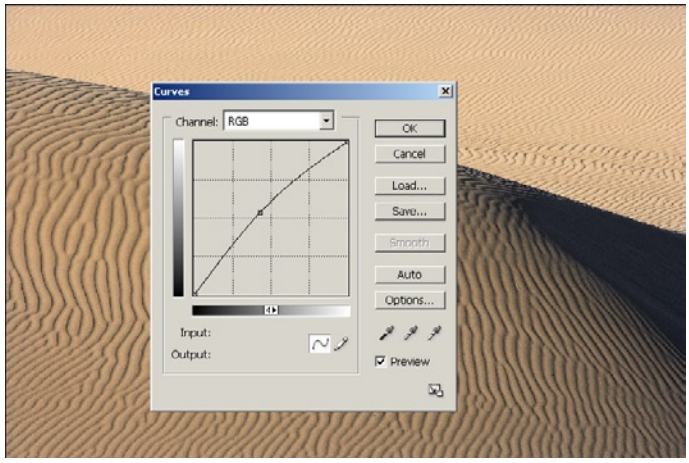


Figure 4-25: Using a Curves Adjustment Layer to brighten the shadow

This technique can be useful when the area you work with does not have complicated edges as boundaries.

Corrections related to certain tonality ranges (shadows, midtones and highlights)

Often, we use a technique to restrict the effect of Curves and other tuning tools to only certain tonal areas:

- Shadows (e. g. opens up shadows)
- Midtones (e. g. adds contrast, brightens and darkens)
- Highlights (e. g. toning down aggressive highlights)

All our masks are based on a Luminosity mask similar to the B&W image of the original photo. We may invert this mask and also restrict it to certain tonal regions. Because this process can be quite tedious, we created our DOP Tonality Toolkit [10]. Here is an example:

Figure 4-26: Original dune photo

As before, we want to open up the shadows. First we create a shadow tonality mask:

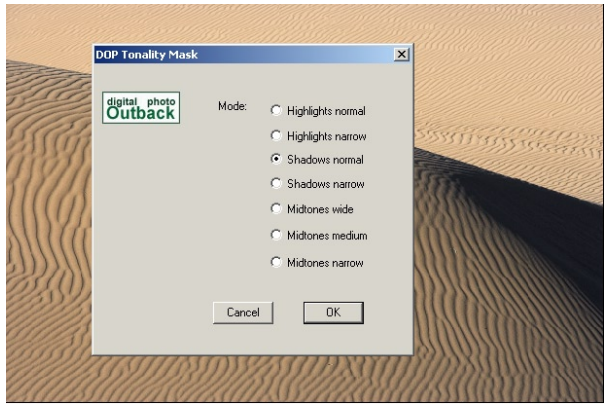


Figure 4-27: Use the Tonality Mask automation plugin to create a shadow mask

We get the following selection:

Figure 4-28: Shadow selection

Again, we use Curves with the selection applied to a Layer Mask:

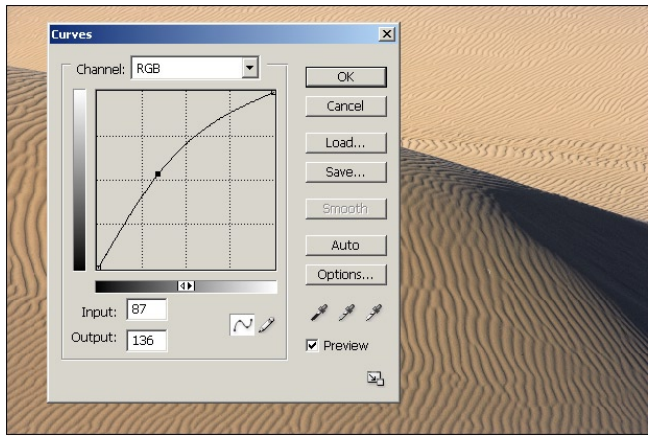


Figure 4-29: Curves applied to shadows only

Here is the Layer Mask that we created:

Figure 4-30: Tonality Mask (shadows normal)

Just for demonstration, we show the mask that would be created if we had chosen the "shadows narrow" option.

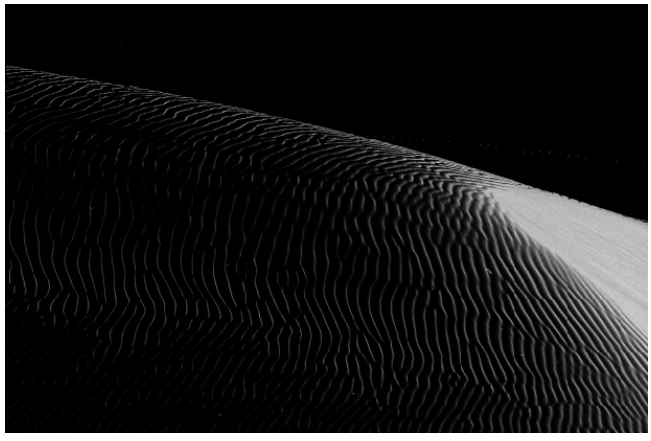


Figure 4-31: Tonality Mask (shadows narrow)

Different from the mask in the last section, we created these tonality masks which include all the shadow parts (even the dune ripples). Whether this effect is intended by you or not is based on how you want to present the print. This last method exaggerates the soft character of the shapes (reduced contrast) while the previous method shows more highlights in graphic patterns of the shapes. It is always helpful to have multiple ways to explore the potential of your photos for printing.

It is fairly easy to modify thse masks using the following painting techniques.

Painting techniques (mainly Dodge and Burn)

In principle, you can paint all your masks (layer masks) with soft brushes.

Painting using Layer Masks

Figure 4-32: Original image

In this example, in figure 4-30, the eye and part of the head of the Avocet chicken are in the shadow. We would like to brighten them up.

1. We create a Curves Adjustment Layer to brighten the whole image.

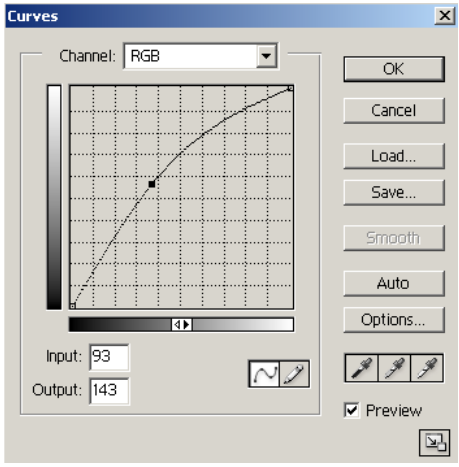


Figure 4-33: Curve to brighten up the image

The resulting image of figure 4-34 is clearly too bright. Don't worry.

Figure 4-34: This image, brightened up by Curves of figure 4-31, is too bright.

2. Using the paint bucket, fill the layer mask with black (be sure you have selected the layer mask when applying the black paint bucket):

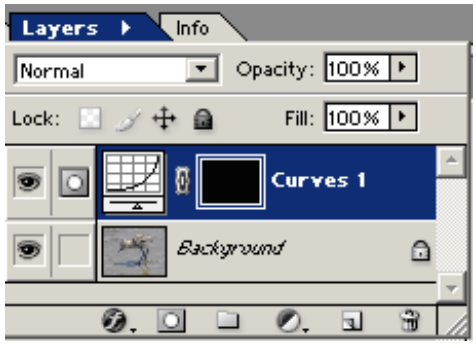


Figure 4-35: When the layer mask is completely black, the adjustment layer has no effect.

The black layer mask hides all the brightening effect of this layer.

Figure 4-36: The effect of the Curves Layer is completely masked by the black layer mask.

3. Using a soft, big brush
   - Color White
   - Opacity 15%

   paint a few strokes over the face. By using 15 % opacity, you have a lot of control in brightening the face (try even higher opacity to experience the difference).

   A look at the Layer Mask (❶ click on the layer mask thumbnail) reveals the secret.

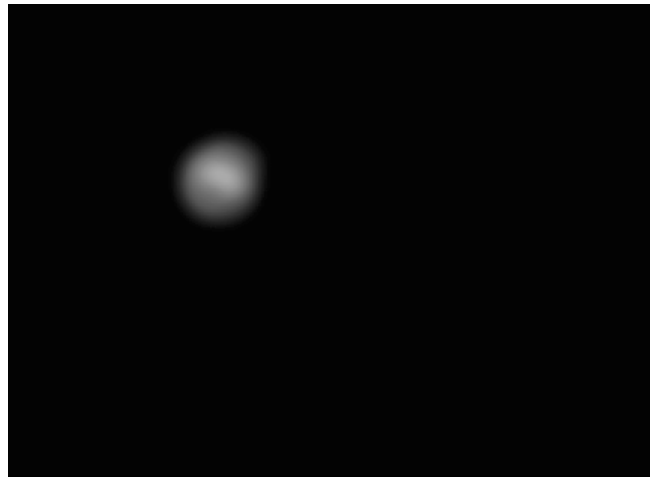


Figure 4-37: Layer mask after painting with the soft white brush.

This is a universal technique for selective image enhancement and can be used with many different types of layers:

- Layer with a sharpened version of an image
- Layer with a noise-removed version of an image
- Hue/Saturation Adjustment Layers
- Curves Adjustment Layer using S-curves

Dodge and burn using Layers

With the same sample image we show a different technique.

Figure 4-38: We want to brighten up the bird's body

1. Create a new layer in the layer palette

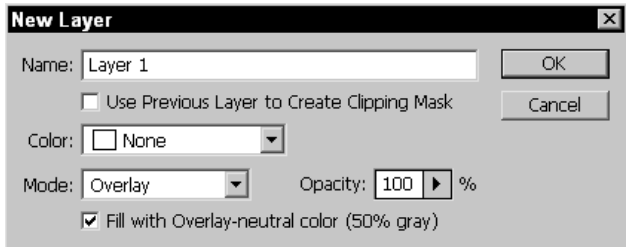


Figure 4-39: Create a new layer with Overlay Blending mode

2. Set *Mode* to *Overlay* and select Fill with Overlay-neutral color (50% gray).

Overlay is a very special blending mode with the following properties (for more details consult Photoshop Help)

- 50 % gray leaves the image unchanged (that is why we start there)
- Painting with values below 50 % gray will darken the image (black being strongest)
- Painting with values above 50 % gray will lighten the image

3. Select the Dodge Tool

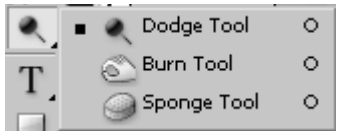


Figure 4-40: Select Photoshop Dodge and Burn tools

4. Set exposure to 5–15 %. Enable the Airbrush option and use a reasonably large, soft brush.

Now, when you paint on areas that are too dark for your taste, they will brighten the more you paint in that area. The lower the exposure, the more you need to paint, giving much greater control.

Figure 4-41: Select your dodge options

5. Dodge the bird's head and body with a few careful brush strokes.

If you make all other layers invisible you can see what your dodge & burn layer looks like.

Figure 4-42: Shows only the Dodge & Burn layer

Dark areas would show portions used to burn (no burning here) and the bright ones are those used for dodging. The following picture (blending of the original picture and the Dodge & Burn layer) illustrates our point. Here is the resulting image (figure 4-40):

Figure 4-43: Avocet has improved brightened shadow

4.3 Tuning colors

We assume you have the white balance of your image as you like it. Color tuning involves fine tuning of colors and not major color corrections.

One of the key issues often considered is to achieve the correct saturation. Be sure the contrast is correct before even thinking of tuning saturation. Frequently, the proper contrast takes care of any issues you may have with too low saturation.

Selective saturation improvements

Often times, we perceive an impression that a digital photo may require increased saturation. Actions and filters to do this are quite popular. Let me open with some general comments:

There is a tendency – introduced by film such as Velvia – to have too great a saturation in photos (larger than life) and lose other subtle, natural colors. When you place two photos side-by-side differing only in saturation, the one with greater saturation draws your attention more. Does that imply it is better? Usually not.

Before you even consider enhancing saturation, get the contrast right. Some S-curves might do the trick.

But then, there are times when you want (need) a bit more saturation. Yet whenever we use tools to increase global saturation, we are less than pleased.

An article by *Ben Willmore* in the Photoshop User magazine changed our whole world. The article was called "Saturate your World". We were a long time admirer of Ben's articles in the 'PEI' magazine, and now of his series in the Photoshop User magazine (magazine of the National Association of Photoshop Professionals or NAPP). Whenever you come across an article by Ben, read it. Also his excellent book on Photoshop CS2 [4] is now part of our library.

At first, his message sounds pretty obvious: "Use selective saturation in Photoshop." Why hadn't we done this before? It seemed complicated, and it actually is when you try it on your own without Ben's guidance. But he gives a wonderful practical tutorial on how to master selective saturation enhancement.

Now, we believe that global saturation enhancement is wrong most of the time. We'll go even a step further by applying selective saturation enhancement to only selective areas of our photos.

Here is an example:

Figure 4-44: Grand Canyon: Mather Point

We want to enhance saturation in the top part of this photo yet retain the bottom as is. Create an adjustment layer using Hue/Saturation. Then, change the layer mask in this layer to something resembling this:

Figure 4-45: Black to white gradient used as a layer mask

The black portion prevents saturation changes at the bottom but allows a soft transition to white in the upper areas.

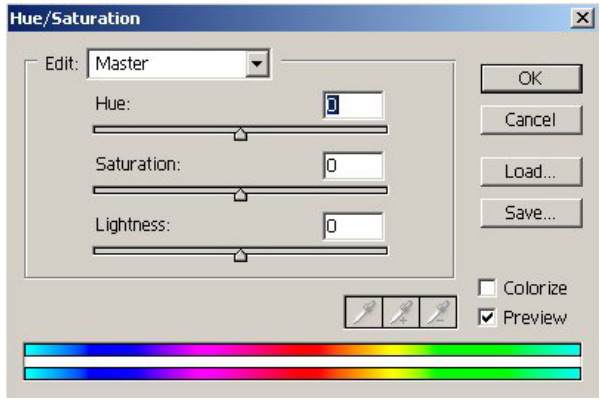


Figure 4-46: No changes done in "Master"

Then, open the Hue/Saturation dialog, but do not change the "Master" settings. We altered the reds using the "Red" settings.

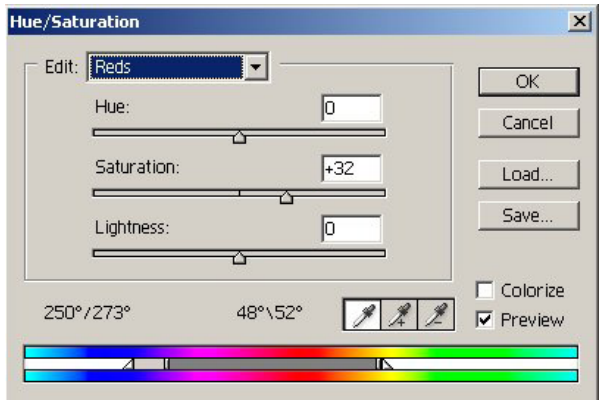


Figure 4-47: For our image of figure 4-44 we do our settings in 'Reds'

We do not want to repeat all Ben wrote, so please learn for yourself what the different sliders mean.

Figure 4-48: Image after selective Hue/Saturation corrections in 'Reds'.

Here is the result of this operation. We concluded that the change might be a bit too strong and considered changing the saturation settings. Instead, we modified the opacity of the adjustment layer.

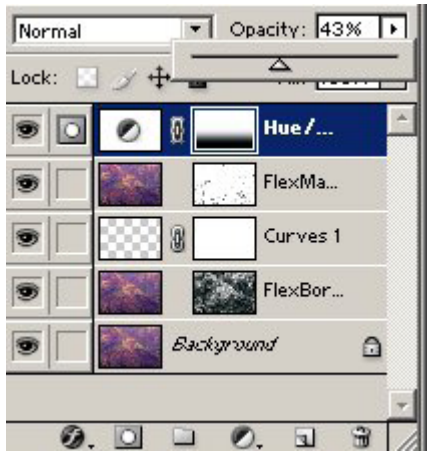


Figure 4-49: Different tuning layers (Adjustment Layers) of the final image

Here is our final version:

Figure 4-50: Final version of our image

The differences can be subtle, but this is precisely what selective saturation is all about: **Think selectively!**

More saturation and contrast tricks

As all photographers learn, there is rarely anything better than the 'right light'. Especially true in our recent book called *Earthframes* (see [5]) we made are the following choices:

- Mid-Day sunlight creating harsh shadows and burned-out highlights
- Evening sun with better light but longer shadows
- Overcast providing flat light

From these 3 alternatives, we favor 'overcast'. Best might be a very light overcast so that lighting is like an optimal light box.

Figure 4-51: Flat image to start with

We probably get some flat images directly from the raw converter. True, we could tweak the raw converter (sometimes, we do that), but usually we prefer to do this work with layers in Photoshop. In that way, we are able to revisit all changes and improve upon them at a later time. The first step is most often an adjustment layer using Levels.

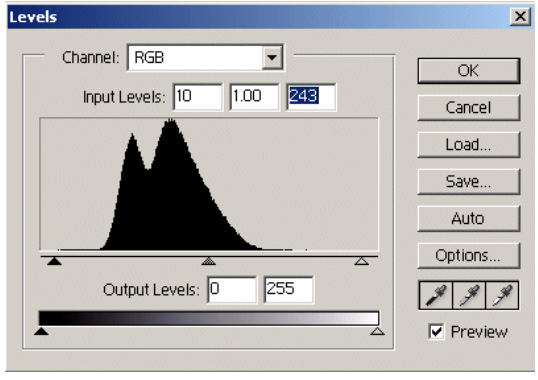


Figure 4-52: Levels Adjustment Layer

As you see, we did not move the white point much, as the photo would get too bright and would not retain truly white details.

Figure 4-53: After Levels

Now, increase the contrast using some S-curve in a Curves adjustment layer.

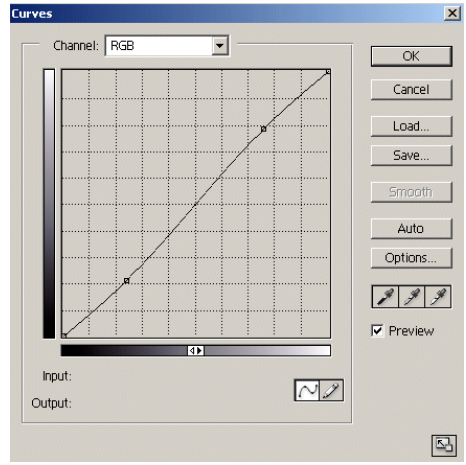


Figure 4-54: Slight S-curve for a bit more contrast

Figure 4-55: After Curves

S-curves tend to create color shifts that can be removed by changing the blending mode of the layer to *Luminosity* (this change is subtle, so best you try it yourself).

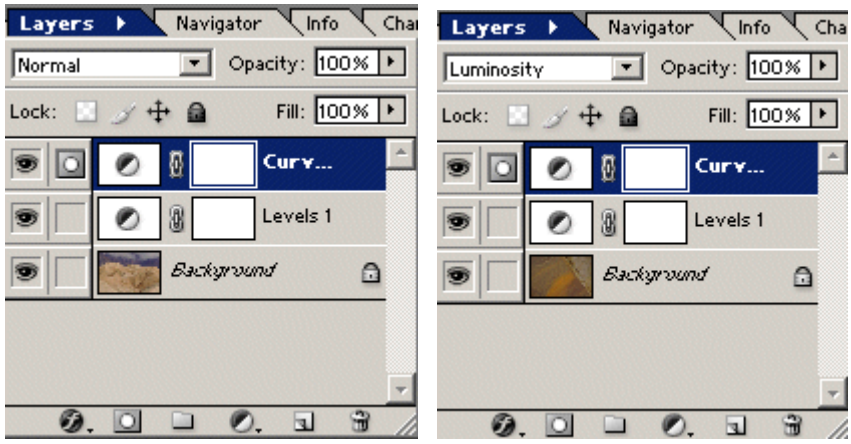


Figure 4-56: Changing blending mode to luminosity

Figure 4-57: After change to 'Luminosity'

There is still a desire to increase saturation and micro contrast, and there are several ways to go. We'd like to explore a technique outlined to us by Katrin Eismann, author of "Photoshop Restoration & Retouching" [6].

Using an adjustment layer with 'Hard Light' blending mode

Create a new Curves adjustment layer and change the blending mode to *Hard Light*.

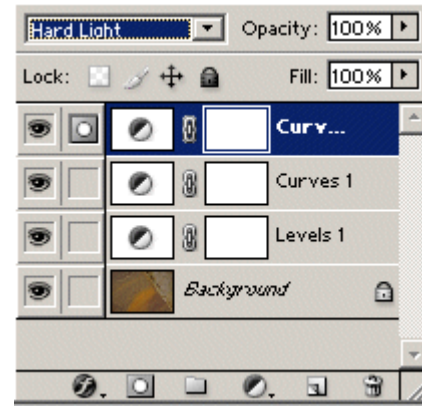


Figure 4-58: Additional Curves adjustment layer using 'Hard Light' blending mode

Figure 4-59: Image with 100 % 'Hard Light'

It becomes obvious, this is not what you want. Right? Don't worry. The right selection of layer opacity allows us to tone the effect down to a more pleasing level.

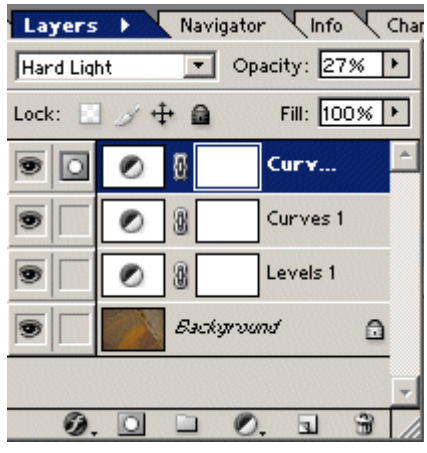


Figure 4-60: Changing the Opacity

Figure 4-61: Opacity of 'Hard Light' layer reduced to 27 %

A problem can occur in using this technique: Shadows might become too dense. Since we use a Curves adjustment layer, we could use curves to control the impact on the shadows, but there is a more elegant solution. Open the layer's blending options and move the left slider for the *Underlying Layer* to the right. Now below 46, values are no longer affected.

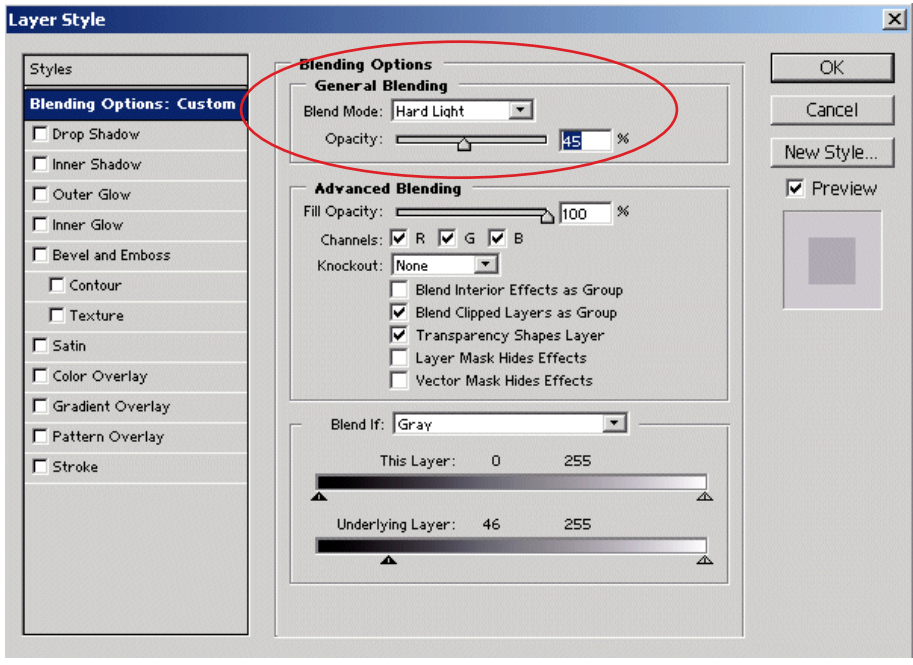


Figure 4-62: Setting the 'Blending Options'

This is still not what we want, as the transition would become visible. Wait, there 's more. If you look carefully, notice that the tiny tri-

angle sliders are split! You can separate them by using the Alt key and moving the right portion of the triangle to the right. Voilà:

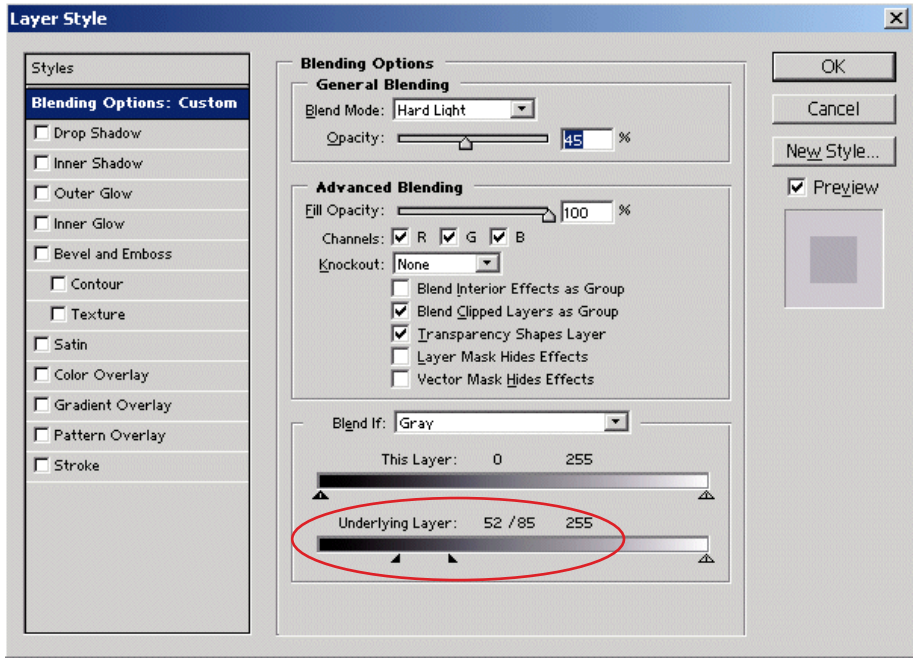


Figure 4-63: Split sliders

Now, all shadows below 52 are protected from our 'Hard Light' layer, and there is a smooth transition zone up to 85. Finally, the layer effect is fully visible above 85.

Variation with 'Soft Light'

You can do the same thing using the *Soft Light* blending mode. This time, the effect is less dramatic.

Figure 4-64: Soft Light at 100 % opacity

Figure 4-65: Soft Light at 27 % opacity

Be cautious lest your photos become too punchy. Also photos directly contrasted using strong saturation appear even flatter than they really are. This is one reason naturally saturated photos are perceived as flat. We are bombarded with too many overly-saturated photos today (the heavy metal of photography).

Removing blue shadow casts

We revisit our dune photo again.

Figure 4-66: Dune

This time we look for at blue cast in the shadows. Be aware that this scene was actually illuminated by two light sources:

- Sun or sun-in-overcast
- Sky in the shades

The light actually has two different color temperatures. In this situation, the global WB should be selected to correct for the main light source (here the sun).

In shadows we detect quite a bit of blue shadow cast (often not too easy to see on screen). We don't like an extreme blue cast in our prints and usually try to tone it down. The techniques here are shown at a 100 % magnification crop (all screen shots).

Figure 4-67: Crop of the original photo

We added a Hue/Saturation adjustment layer to pump up the blue to intensify the cast:

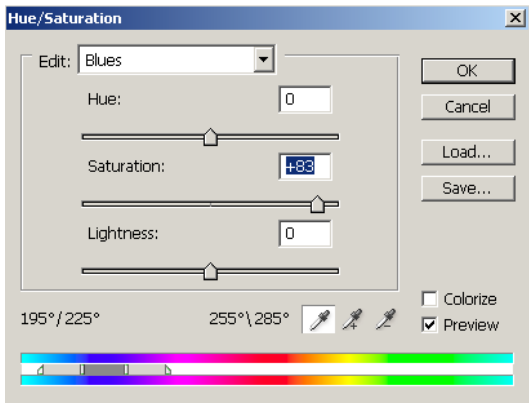


Figure 4-68: Adjustment layer to increase the saturation

Figure 4-69: Visualize the blue cast

As stated, the blue cast looks much too strong, but it gives an idea where blue cast resides. As shown in our books, we use selective Hue/Saturation to tone down this cast (we keep the test Hue/Saturation layer on top, just to show the effect):

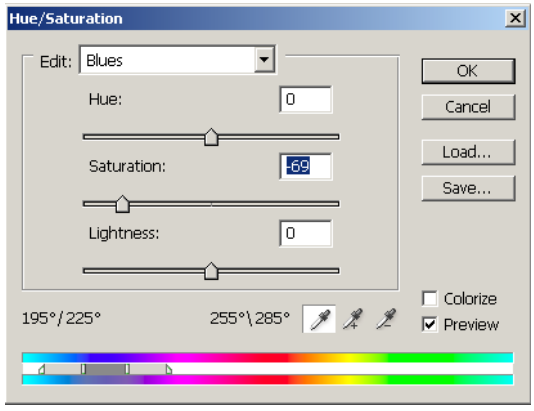


Figure 4-70: Selective reduction of the blue cast

Figure 4-71: Blue toned down

A nice side effect of all this is that shadows get a bit brighter when we tone down the blue. It is possible that this strong removal might prove a bit too drastic, and we may want to limit the blue reduction to shadows. This is why we used our Tonality Tuning Toolkit and created a mask to limit the Hue/Saturation layer only on the shadow portion of the image:

Figure 4-72: Reduced blue removal

Note: We often use the same shadow mask to limit the effect of a noise removal layer to the shadow part of the image. These shadows can show a lot of noise.

Remember, our Hue/Saturation test layer still strongly amplifies the blue. Next page is the final version after disabling the Hue/Saturation test layer (figure 4-69):

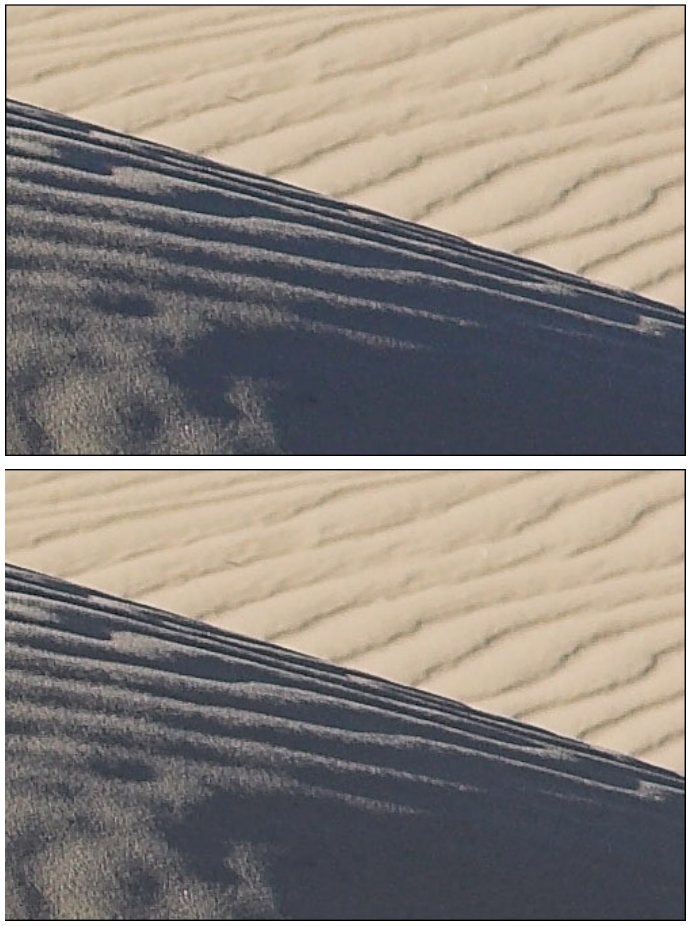


Figure 4-73: Initial (above) and final version of the image

Sometimes. the difference is not as impressive on screen as it can be in a print.

Of course, you must be careful if other blue areas reside in your image (e.g. sky). In that case, you may use masking techniques also to protect those areas.

4.4 Sharpening

All images stemming from a digital camera need some sharpening, as some softness is introduced internally by the anti-aliasing filter of the digital camera (in front of the sensor). Some additional softness is introduced by the demosaicing filter. With digital scans, some softness is produced in the digitalizing process. Some sharpening is called for, in any case. Sharpening usually should be performed as the last optimization step – regardless, after removing noise, sharpening may make noise more visible. There actually are two types of sharpening you should apply to an image:

A) **Some general sharpening**, to improve an image, independent of the output method

B) **Output-specific sharpening.** If the output method produces additional softness – e.g. due to dithering as used for offset or ink-jet printing – you would apply more sharpening to compensate for this. If your output method does no dithering – e. g. say for presentation on monitors, or when using dithering-free printing such as lightjet printing or output on a dye-sublimation printer – no additional or only slight sharpening after step A is required.

The second kind of sharpening should be done after final scaling for output, as sharpness is influenced by up- or down-sizing of the image. Ideally, scaling and sharpening may be left to the printing process (e. g. RIP) if this process offers such a feature.

Please consult our e-books DOP2000 ([20]) and DOP3002 ([22]) for more details on sharpening.

Personal note on sharpening by Uwe

I try to sharpen an image at the camera's resolution so that I can see as few artifacts as possible (at 100 % magnification), but still keep the image in focus. Later on, I try to avoid too much up-sizing (see next section) and do hardly any extra print sharpening. This ensures a natural sharpness for the print. Too much sharpening always makes prints look so *digital* (meaning *less smooth*). It is no surprise that I use my own sharpening tool, EasyS Plus Sharpening Toolkit, (see [11] and [12]), and there are many other valid sharpening strategies, as well.

4.5 Resizing

As in *Sharpening,* resizing is a complex topic. For printing we mainly deal with up-sizing only after the print sizes becomes larger. There are two main reasons to perform some up-sizing:

- Bring the ppi (pixel per inch) up to a value that is optimal for your printer. Most printers work fine with the original ppi between 240–360 ppi. Some even use 180 PPI and leave the further up-sizing to the printer driver.
- Make significantly larger prints than the original image size and ppi would normally allow. We rarely try this, as it always means 'inventing' many new pixels. Admittedly, good up-sizing algorithms can create wonderful illusions.

When you perform major up-sizing, you normally need to add final sharpening.

In Chapter 6 "Printing with Printing Packages and RIPs," we feature Qimage. We like Qimage, because it does all these things:

- Use first-class up-sizing algorithms
- Up-sizes to a printer's native resolution (Epson 720 ppi, and HP 600 ppi)
- Applies some mild amount of final sharpening that often results in some nice local contrast enhancement.

If you really must up-ize your image first – which you should do if you want to print an up-sized image using Photoshop and the standard printer driver – there are up-sizing tools we recommend:

- Photoshop *Bicubic Smoother*: does a nice job for moderate up-sizing
- DOP Up-sizing [35]: Our free automation plugin that implements a strategy by our friend Jack Flesher.
- Genuine Fractals: the classic up-sizing tool, but slightly expensive.

Note: If you have to resize an image, never do it to your master image but only **to a new copy of the image file!**

4.6 'Ring around' and Variations

This chapter covers material strongly influenced by our friend Brad Hinkel.

Finally, only an actual print can show how a print looks. 'Soft-Proofing' is just one way to get as close in quality to the final print as possible. We want to cover here two important techniques in fine-tuning your prints:

- Ring Around
- Variations (on screen and in print)

Both techniques are based on seeing the same image (or partial image) in variations of the original to verify you get the interpretation of the image you like the most.

Ring Around (text by Brad Hinkel)

Printing a 'ring around' is a traditional technique for evaluating images in the wet color darkroom. I did it for my basic color printing class. I found the process useful, but far too tedious to repeat for any image other than that particular assignment.

Figure 4-74: 'Ring Around' scheme

In the digital darkroom, this procedure is still effective, but infinitely easier. The 'ring around' is designed to help evaluate if an image has the appropriate color balance and/or density. (It can potentially be used for a wide range of options; anything that can be placed on an adjustment layer; we will be investigating more options in the future.) The basic ring around shows some variations of an image for +R, +G, +B, -R, -G, -B, darker and lighter.

Use a Ring around:

- when you have an image you think looks great – but just to test the final evaluation,
- when you have an image that you just can't seem to color balance well.

It is important to remember, that our eyes/brains will sometimes compensate for color balance issues in an image to make it appear better than it really is. So, take time away from an image (even a couple of minutes) and return to it to evaluate its color. A 'ring around' forces a better evaluation of color.

We automated the whole process. The action provided helps to create a 'Ring around' quite easily (sorry, this action is for PC, as we need to write to disk, but the action is a blue print for your own actions on a Mac).

- We create a folder (PC: "C:\tmp\ring_around")
- Empty the folder
- Run the action
- Browse to the folder in Bridge or the Photoshop file browser
- Run the Contact Sheet II tool from Bridge or Photoshop

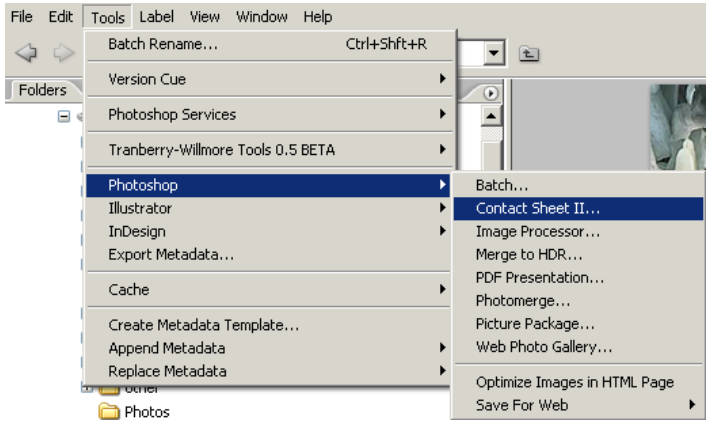


Figure 4-75: Calling Contact Sheet II from Bridge

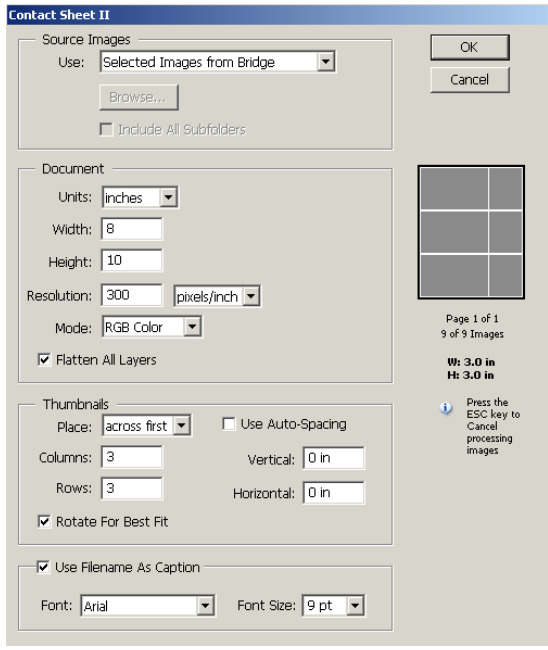


Figure 4-76:
Contact Sheet II dialog

- Select a 3 × 3 matrix
- Enable a filename as a caption
- Confirm OK
- Photoshop will create a one page proof sheet
- Print it using the appropriate profile

You can find and download our free Photoshop action for 'Ring Around' at [80].

Using Variations

Fine-tuning an images costs at least as much effort as getting the image in the first place. Here is a technique to help you visually optimize pictures. These routines look simple, yet they really help for that which they are designed: Fine-tuning.

We have implemented this technique in a 'DOP Variations plugin', and you can do the same steps by hand.

Comparison is a powerful tool in optimizing color, brightness, contrast, saturation and more. There is a nice tool in Photoshop called *Variations* (Image ▸ Adjustments ▸ Variations) that guides you through a sequence of image variations (see figure 4-73).

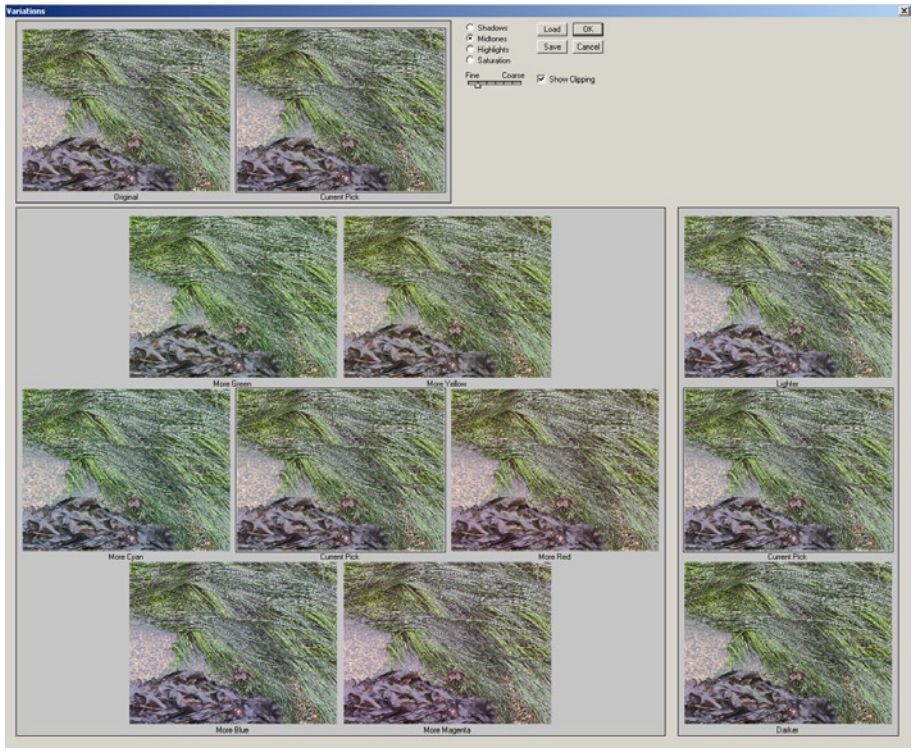


Figure 4–77: Photoshop Variations

It is a nice tool, but has some major shortcomings when seriously attempting to do fine tuning:

- Images are much too small
- Once confirmed, a change is 'cast in stone' and cannot be edited – it would be nice to make it an adjustment layer.
- Not easy to customize

When our friend Brad Hinkel brought 'Ring - Around' to our attention, it got us thinking about a better method to use variations. Our goals were:

- Use the full Photoshop image to compare
- Have different comparison patterns
- Correct in iterations
- Leave all corrections in adjustment layers (nothing cast in stone)
- Preview before and after at any time
- Easy to customize
- Not waste too much disk space

DOP Variations

Though this is our own tool, feel free to create your own variations workflow using Photoshop actions. (You will find our tool at [81].)

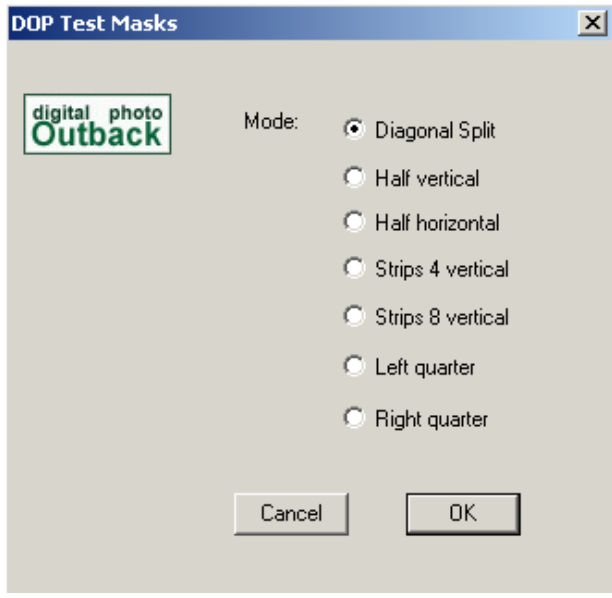


Figure 4-78: Different comparison masks (only available in the Windows version of the plug-in)

As with many good ideas, it is really very simple. The plug-in creates adjustment layers with layer masks that are used to compare before/after scenarios. Here are the masks you can select:

Figure 4-79: Masks, you may use with our Variation Plug-in

The next two masks will be used for the "Left/right quarter" option and provides an alternative method of comparing:

Figure 4-80: Variation masks

We use this same image also in our full variations workflow:

Figure 4-81:
Starting image

Let us assume, that you use mask #1 ("Diagonal Split"). Then, the action '*DOP Variations Layers*' will create a layer group (or layer set) with layer masks that use mask #1. It would look like the following image:

Figure 4-82:
Split layer mask #1

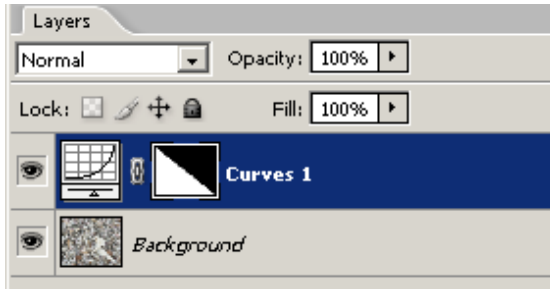


Figure 4-83:
Layer palette showing the Curves adjustment layer with its layer mask

Figure 4-84: Split layer mask #1

The goal of the mask is to provide an aid to see the difference between 'before' and 'after.' The adjustment layer is easily tuned using opacity to reduce the brightening effect. Its full benefit will be shown in our next full example. Here, we want to provide information on how these variations work, in principle.

The full optimization workflow

Again, we start with an original file. This time we use the supplied action called '*DOP Variations Layers*' and use option 1. This creates the layer structure of figure 4-81.

The plug-in, together with the actions, creates a layer group (before CS2 called *layer set*) with all layers disabled. We get 12 Adjustment Layers:

- Blue plus/minus Color Balance (+30/-30 at 50 % opacity)
- Red plus/minus Color Balance (+30/-30 at 50 % opacity)
- Green plus/minus Color Balance (+30/-30 at 50 % opacity)
- Darker/Brighter Levels (0.8/1.2 midpoint at 72 % opacity)

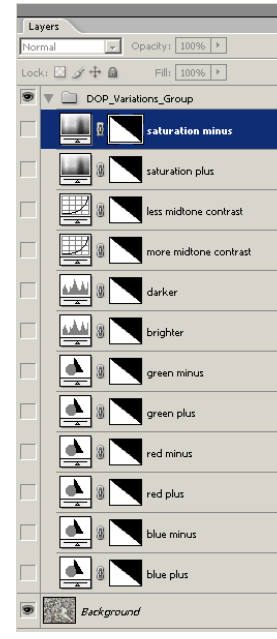


Figure 4-85: Layers

- More/less midtone contrast S-Curves (at 80 % opacity)
- More/less saturation (+20/-20 at 75 % opacity)
- Warmer/Cooler (Photo Filters at 50 % opacity)

The task is now to inspect each pair of corrections and decide whether a picture benefits from one of the corrections.

Sample #1 Darker

We enable the "darker" layer and see the following image:

Figure 4-86: Image when layer 'darker' is enabled.

We can now tune the opacity of this layer to darken it as much as we like (probably less is more). When we are happy with the result we disable the Layer Mask:

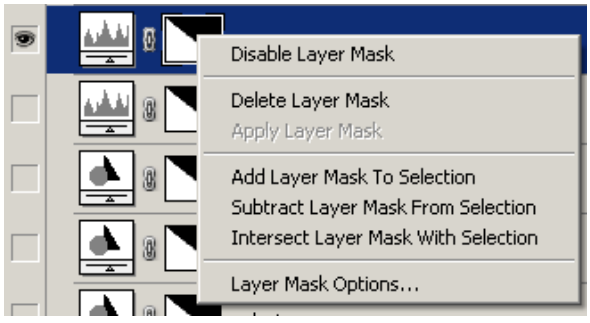


Figure 4-87: 'Disable Layer Mask' in order to remove the partial disabling of the layer effect.

You will get the layer structure of figure 4-84:

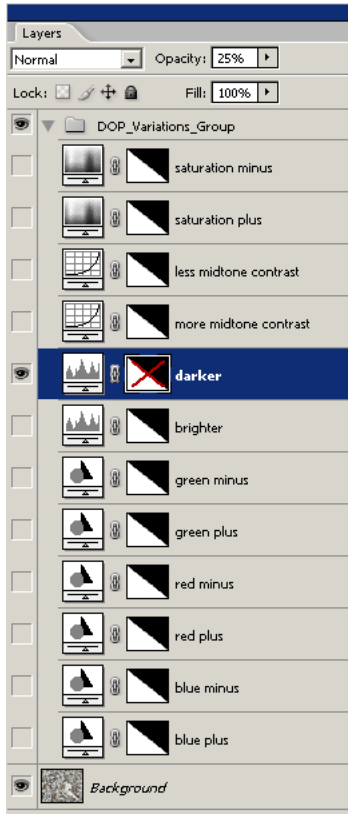


Figure 4-88:
Final layer structure after our optimization using the 'Variation plug-in'. If you keep all disabled layers, you may activate them later for further tuning.

Now "darken" with opacity 25% applied to the full image. Also we can check the global effect at any time by enabling/disabling the complete layer group.

As we perform these tests for each of the layers, in many cases we see right away that this sort of correction may not make sense.

Don't these many adjustment layers blow up a file size? We tested it on a full Canon 1Ds Mk. II file (16.7 MP):

Name	Size	Type	Date Modified
1ds2_0000_2861_no_layers.tif	35,314 KB	TIF File	11/2/2005 7:06 PM
1ds2_0000_2861_one_adjustment_layer.tif	81,230 KB	TIF File	11/2/2005 7:13 PM
1ds2_0000_2861_with_layers2.tif	83,384 KB	TIF File	11/2/2005 7:11 PM
1ds2_0000_2861_with_layers.tif	85,708 KB	TIF File	11/2/2005 7:08 PM
1ds2_0000_2861_one_layers.tif	127,414 KB	TIF File	11/2/2005 7:12 PM

Figure 4-89: File sizes

- Image without any layers: 31 MB
- Image with a single adjustment layer: 81 MB
- Image with the full layer group: 85 MB

This means, the overhead is significant compared to not using layers at all. But because layers are the way to go for fine-tuning anyway, our base size is at 8 MB. In this case, we have about 4–5 MB overhead and this means no more than 5% more than the minimal size for just one adjustment layer.

If you finally like your image, you may start the actual printing, described in the next chapter.

Chapter 5

Fine Art Printers in Practical Use

Camera: Konica Minolta Maxxum 7D

When everything works correctly, printing with today's fine art printers can be a pleasure. Unfortunately, many things can go wrong and spoil the fun. This may sound more daunting than it really is. We want to explain the best ways to use your printers. This implies your need to know when to use or not use certain features of your printer. Knowing the basics gives you the freedom to experiment.

5.1 Printer installation

The physical installation of a printer is similar whether connecting to a Mac or PC. Unfortunately, the software is usually quite different. Typically, we install a new printer in about 15–30 minutes (with some large format printers the ink charging time may take longer) and, in most cases, it is a very smooth process (HP, Canon and Epson).

Connection types

USB/USB 2.0: Currently, USB is the most common type of connection offered by all new printers (frequently, there is no cable supplied in the box). A connecting cable can extend from about 6 to 20 feet. Avoid too lengthy cables. Additionally, you can connect most USB printers via a USB hub (best to use a powered one). USB may, in some cases, cause problems with certain printers (e.g. HP Designjet printers, as we discover later). USB 2.0 ensures a better throughput, and is also the current standard for the newest printers (the speed of most printers is not high enough to challenge the USB 1.0 connection).

Firewire (IEEE-1394): Firewire is less common and not significantly faster than USB 2.0. Firewire allows slightly longer cables, however.

Ethernet: Ethernet allows the longest cables (easily 50 feet or longer). Printers, like the HP Photosmart 8750, come with USB and Ethernet, or you may add an Ethernet network card, as is true with some Epson large format printers. This throughput is adequate most of the time, and using Ethernet allows you to easily share printers among multiple computers. On the other hand, networking can be challenging. If you don't like dealing with a network, we suggest using one of the other kinds of connections.

Parallel: This was the classical type of PC computer-to-printer connection, but has been largely replaced by USB. We would not recommend using parallel with today's printers because of their short/thick cables offering less flexibility.

Note: Do not connect a printer to your computer before the manufacturer's manual or, in many cases, the installation software prompts you to do so.

Unpacking

During physical setup, follow the manufacturer's setup instructions word for word. Place the printer at a location where you can handle all paper input/output easily while providing adequate space for cooling (most printers don't generate excessive heat).

Installing the print heads

Some printers implement removable heads (HP and Canon) while others have fixed ones (Epson). Both are related to the inkjet technology used with pros and cons for both technologies. Overall, this aspect should not affect your choice of a printer other than that you must take the cost of new heads into account in your cost analysis. If you need to install heads (HP and Canon), follow the manufacturer's instructions carefully.

Installing the ink cartridges

Follow the manufacturers instruction word-for-word. Never touch the electronic contacts. The perspiration on your fingers can cause the contacts to corrode.

Calibration, printer tests and head alignment

Some recent printers ask you to insert plain paper to perform an automatic head alignment or color calibration. Both steps may be repeated later, but it is best to do the printer setup as early as possible. Normally, the final test sheet indicates that the printer passed all its tests.

Installing the drivers and other software

Repeat Note: Do not connect the printer to your computer before the manufacturer's manual or the installation software prompts you to do so (usually, after a printer driver is installed).

We repeat this to save you potential problems. All the printers we cover in this book ship with software installation programs to safely guide you through the entire driver installation process, step- by-step. Follow the instructions carefully, and take your time. Some printers come with software other than the driver itself. We rarely install this extra software as we are familiar with our printing soft-

ware (Photoshop CS/CS2, Qimage or ImagePrint) and none of these software packages needs more than their drivers.

Once you have installed the drivers, it is time for a test print. This is merely a print confirming that the connection and the drivers work correctly, not a test as to whether you achieve the print quality and colors you want. We will check that later.

Installing printer profiles

Many modern printers come with generic profiles for the printer. Sometimes, these may require an additional installation step. In most cases, these profiles are installed with the printer drivers. Without them, you will have a difficult time getting good prints.

5.2 Printer adjustments

Though most printers are ready to go after the installation process, some require fine-tuning their behavior.

Head Alignment

Head alignment is crucial for optimum print results without banding. Fortunately, many new printers now use sensors inside the printer to perform this alignment automatically. Check the user manual to perform head alignment, if necessary.

Nozzle Check

Especially when not using your printer every day (if possible you should use you printer at least once a week), some nozzles may become clogged. The Nozzle Check prints a test pattern to show you whether any nozzles are clogged or not.

Head Cleaning

If some nozzles are clogged, you must perform one or more head cleaning cycle. Unfortunately, this procedure uses up some ink (which adds to ink cost).

Color calibration

Some printers perform a color calibration on the printer (e.g. HP Designjet 30/90/130). This has the advantage that a printer can more easily be used with generic profiles as the printer is set to a defined state. Color calibration is best performed after changing heads or inks.

With its new, large-format printers, Epson (4800, 7800, 9800) has tried to avoid this step by using the following measures:

- Very low production variations between printers of the same make
- Fixed heads
- Factory printer linearization

5.3 General driver tasks and settings

Printer drivers seem to be simple tools, yet there are many aspects influencing image quality, not to mention, comfort of the user. Here, image quality should clearly be a high priority.

Settings that influence print quality

Note: All these parameters may influence your choice of profiles. Remember that any given printer profile is only valid for a specific paper, ink set and driver setting combination.

Paper type

Paper type is one of the most important settings in your driver. Be aware that most drivers only allow choosing between papers of the specific printer manufacturer. Third party papers may be a close match or completely wrong. Expect the least problems by staying with the family of papers a manufacturer provides.

With paper type selected, you implicitly select many other parameters of the printer driver, and often there is no other way to select them directly. How these settings work is known only by the manufacturer. Often, there is a lack of a reasonable description of the settings in the printers manual.

- Paper thickness (distance from heads to paper)
- How much ink to lay down
- Drying time
- Paper transport speed
- Possible print quality selections (DPI)

Print quality settings

DPI (Dots per Inch): Each paper wants to be assigned a certain DPI setting. Often, higher values give better results, print slower but often use more ink. Also, in many cases, you may distinguish the difference only with a magnifying glass. We are usually quite pleased with the settings referred to as *Best*.

Color and color management settings

These settings make or break good prints. We provided a full chapter on Color Management to be sure you get the best possible prints.

There are three different strategies in working with printers to create the colors you want.

1. **Let the client application (for instance, Photoshop) handle color management** (File ▸ Print with preview)

   This means the printer should not do color changes at all.

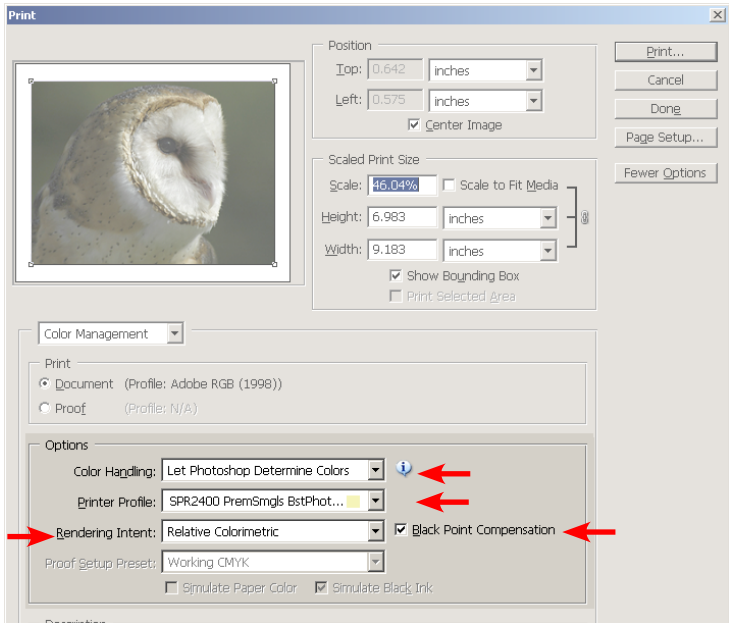


Figure 5-1: Select your CM strategy in Photoshop CS2

Important settings are marked in red in figure 5-1. When color management is done in an application, you must disable it in the driver (figure 5-2). In other words, **do NOT enable it in the application, as well as, in the driver!**

This is our preferred option used most of the time. It is much easier to understand what a client application does than what the printer is doing 'behind your back.'

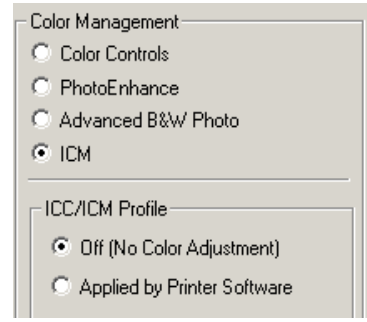


Figure 5-2: Settings to turn color handling off in the driver

2. **Let the printer handle color management.**

   In this case, the client application does not handle profile conversions and leaves it to the printer driver. In almost all cases, this is not a good idea, as you rarely understand what the driver is doing. Only on some printers, printing in B&W, we use this option (covered later in Chapter 7 'Black&White prints').

3. **Use manual or automatic color settings for a printer.**

   We never use such settings as they eliminate proper color management and make printing of correct colors more like a gamble. If you do not use color management, then you should, at minimum, leave your original image in the sRGB color space, as in most cases, the driver would assume the picture is in this space.

   As mentioned earlier, to get the results you want, work on your profiles, and improve them.

Good profiles are your ticket to accurate prints!

Printing Speed

Some printers are faster when printing bidirectional. In some cases, this somewhat decreases image quality. We recommend using this setting only if you can see no difference in quality or when you need sample proofs quickly.

Advanced Settings (ink volume, color density, drying time, …)

Most of the time, you won't need to change any of these settings.

Yet, we have had situations where, for example, the prints on Epson Enhanced Matte paper came out too wet (leading to warping). In this case, we reduced color density to -5 or -10 to solve the problem. If you do this regularly with a paper, you might be wise to create a special profile with these settings.

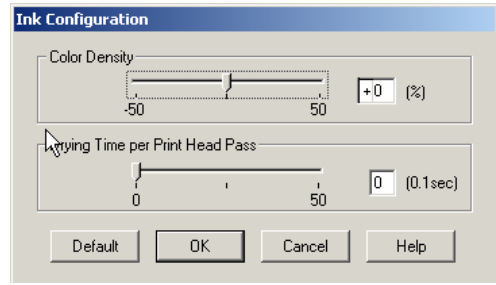


Figure 5-3: Epson R2400 advanced settings

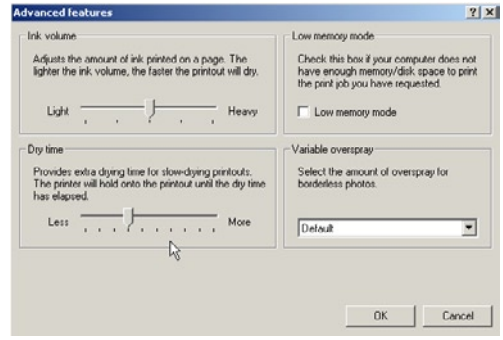

Advanced features
Ink volume
Adjusts the amount of ink printed on a page. The lighter the ink volume, the faster the printout will dry.
Light
Heavy
Low memory mode
Check this box if your computer does not have enough memory/disk space to print the print job you have requested.
Low memory mode
Dry time
Provides extra drying time for slow-drying printouts. The printer will hold onto the printout until the dry time has elapsed.
Less
More
Variable overspray
Select the amount of overspray for borderless photos.
Default
OK
Cancel

Figure 5-4: HP Photosmart 8750 advanced settings

More settings

The settings listed here are not related to image quality, but more to controlling the layout, paper feed and more.

Paper Size ▸ Quite obviously, an important setting. The drivers also allow creation of your own custom paper sizes.

Paper Sources ▸ Most printers have choices on how to feed paper.

- Different trays
- Single-sheet feed
- Roll feeder (which also involves automatic or manual cutting; Check whether a built-in cutter can handle your paper's weight)

Paper orientation ▸ Select landscape or portrait mode.

Borderless printing ▸ We have little experience using this mode as fine art prints nearly always have a border (at least an inch) to simplify matting.

Number of copies ▸ Normally, you can select the number of copies in the client application's printing dialog.

Scaling ▸ We recommend performing any scaling in the client application, such as Photoshop.

Print preview option ▸ We rarely use this option. Sometimes it makes sense to check whether your prints have the expected orientation and size.

Warning: We have heard users say that their prints looks "wrong." Eventually, we learned these users had never actually printed their images, but were merely viewing the Epson print preview screen. Do NOT judge the ultimate colors of prints on the Epson print preview window. They display without color-management and can be completely inaccurate, often tending toward magenta. This may be fine as this is only an indicator that a printer needs stronger corrections to print correctly.

Ink level monitor

Checking ink levels is important, but can also be confusing. When some ink indicates as low, have replacement cartridges available. Manufacturers want you to change ink as early as possible (more money for them). The following has been our experience with two different printers:

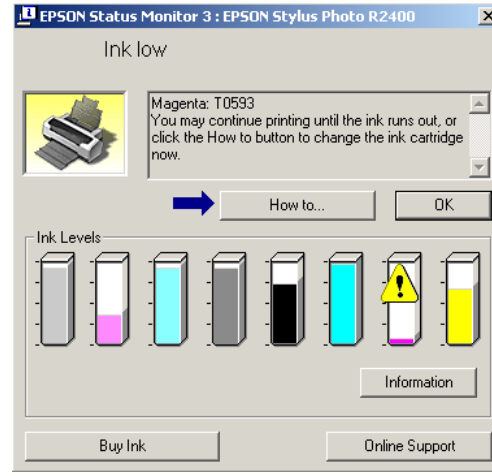

EPSON Status Monitor 3 : EPSON Stylus Photo R2400
Ink low
Magenta: T0593
You may continue printing until the ink runs out, or click the How to button to change the ink cartridge now.
How to...
OK
Ink Levels
Information
Buy Ink
Online Support

Figure 5-5: R2400 ink level monitor

Epson Stylus R2400 We wait until the printer stops printing before changing an ink cartridge. So far, we find that we have not lost a single print in doing this.

HP Photosmart 8450 We do not switch the cartridge immediately when we get a warning. It may be a good idea, however, not to wait until the cartridge is completely empty as these particular cartridges contain 3 different colors of ink, and you may be low on only one. Waiting too long may cause pages to print with degraded quality.

Printer driver settings with Mac OS X

There are many variations of an MS Windows printer driver interface greatly dependent on the printer manufacturer. Even the driver dialog boxes of the same maker show many variations when handling different printers from that maker. While the major part of this chapter uses Windows-based examples, we want to provide the driver setting scheme for Mac OS X.

The difference is significant when switching to Mac OS (we focus only on Mac OS X). However, the similarity in various driver dialogs is much stronger in Mac OS, as Apple supplies a good framework for this. The Mac OS X basic driver dialog hierarchy looks like this:

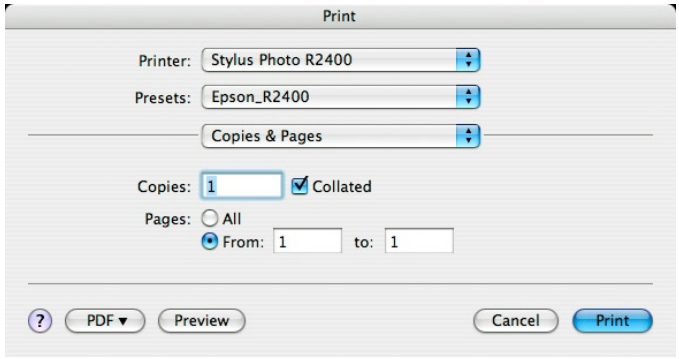
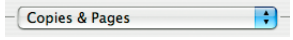


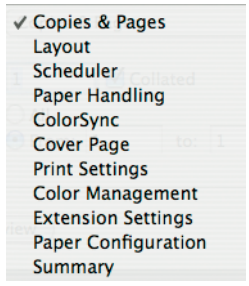
Figure 5-6: Basic print dialog with Mac OS X.

Printer Choose the printer you wish to print on.

Presets If you have saved some printer settings previously, you will find those names in the drop-down menu. Load a set by selecting its menu item. Otherwise, use *Standard,* and make individual settings in the various dialog boxes selected from the following drop-down-menu:



This is a pull-down-menu where you find most of the various settings dialog boxes for the printer. There is a basic scheme, and menu items are there for nearly all printers (e.g. *Copies & pages, Layout, Scheduler, ColorSync* and *Summary*). Some menu items are printer and manufacturer specific (e.g. *Print settings, Extension Settings* and *Paper Configuration*).



Here is a short explanation of the various menus and settings:

Layout Here you may specify that you want to place several images on one sheet. For fine art printing or casual photos this is not useful, as placement is arbitrary. If you want to do an index print or place several images on one sheet, you can use Photoshop or other application to do this. This dialog box changes slightly, when a different printer is used.

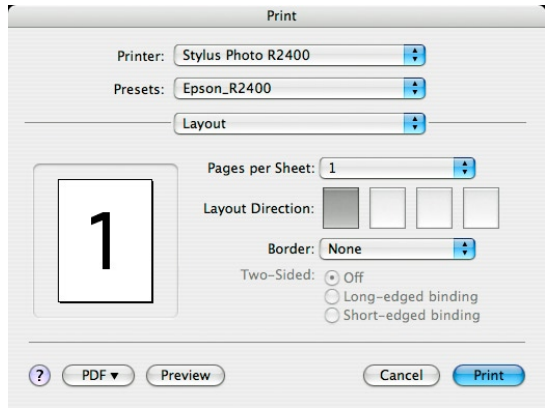


Figure 5-7: Mac OS X Printer Layout tab

Schedule You may specify when the print job should begin. With fine art printing, you usually want it to start right away (*Now*), which may be the default in the print queue.

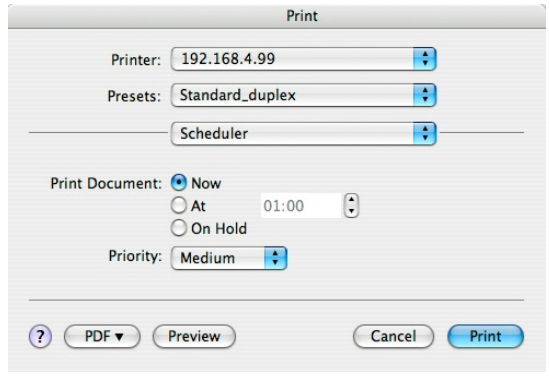


Figure 5-8: Mac OS X Printer Schedule tab

Paper Handling
You may scale your print here, which is fine, when slight scaling is required. For fine art printing, scaling should be done either when preparing the image for print (see Chapter 4) in Photoshop or should be left to the RIP when using one. If you print a portfolio having a multi-page document and want to print duplex without having a

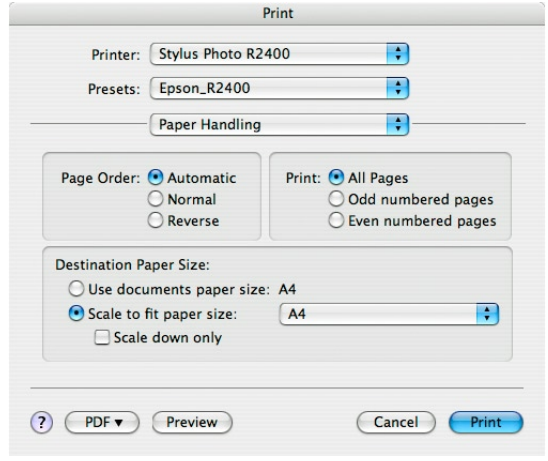


Figure 5-9: Mac OS X Printer Paper Handling

printer equipped with duplex capability, you may use the scheme of first printing all *Odd numbered pages*, re-inserting the paper stack and then printing *Even numbered pages,* while activating *Reverse*.

ColorSync Here you select how the Mac OS X color management system is involved. You may do some image preprocessing using Quartz filters, which, we recommend not to be used when printing directly from Photoshop.

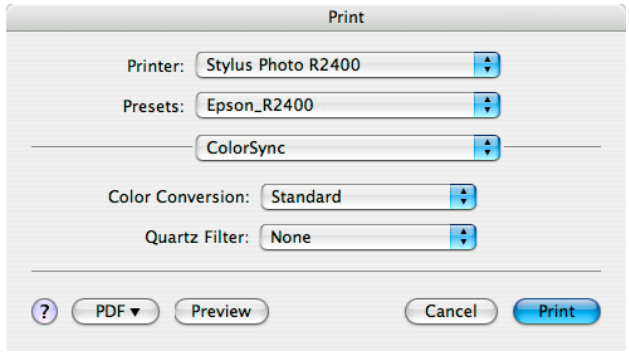


Figure 5-10: Mac OS X ColorSync tab

ColorSync setting are useful when printing from an application not color-managed. In this case, ColorSync may take over and provide color management – e.g. mapping image color from the image color space to the printer color space. However, you can't select the printer profile from the printer driver dialog from here, but must do that setup using the ColorSync Utility (found in Applications > Utilities > ColorSync Utility). See Mac OS help for more information.

Cover Page allows specifying if you want to print a cover page for which in fine art printing may be undesirable considering the cost of fine art paper and expensive ink.

Printer Settings
These are the most important settings in fine art printing. This dialog box is printer and manufacturer specific, resembling Windows printer driver dialogs. Here is an example of the dialog for the Epson R2400 printer:

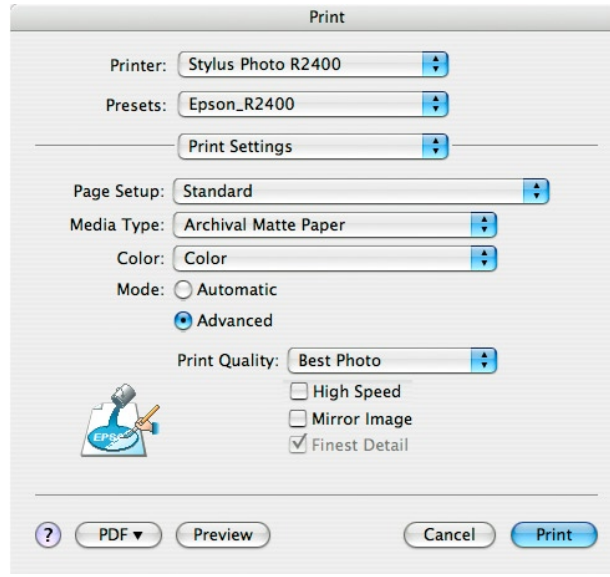
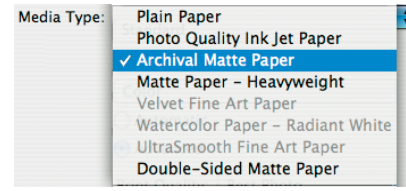


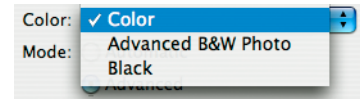
Figure 5–11: With 'Printer Settings' you do most of the settings for your print.

- **Page Setup** with the R2400, you are given a choice between *Standard* (Sheet Feeder) and *Paper Roll*.

- **Media Type** Select your media (paper) here. The R2400 printer driver only offers those media working together with the type of black ink cartridge in place – either *Photo Black* or *Matte Black* (the latter was inserted as the screen shot was taken) and grayed out all unsuitable medias. The driver interface only offers Epson media. If you use a third party paper, you must estimate which Epson paper is the closest equivalent.

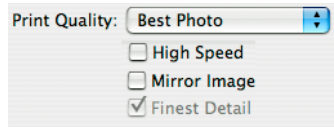


- **Color** For the R2400 you may either print in *color* (obviously the right choice for fine art printing), *B&W*, which we select for B&W printing (see chapter 7) or *Black* only, which is useless for our purposes.

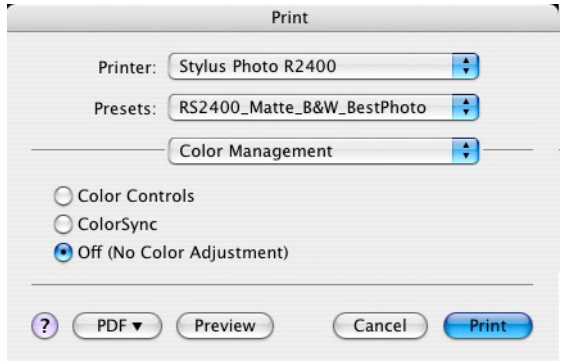


- **Mode** For fine art printing, select activate *Advanced*, so that the dialog will show the advanced settings for the printer as shown in figure 5-11.

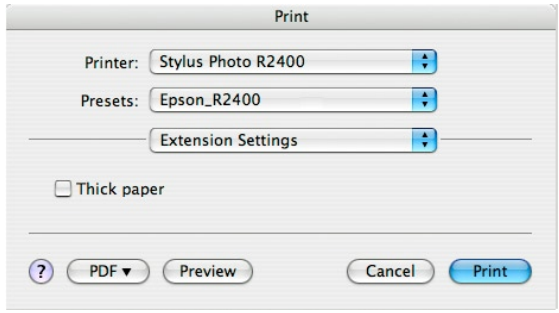
- **Print Quality** The drop-down-list will offer different printing qualities, depending on the media type selected (e. g for plain paper, only *Economy* and *Fine* are enabled). For fine art prints using the Epson R2400 we recommend *Best Photo*. Below that, we disable *High Speed* and activated *Finest Detail*.



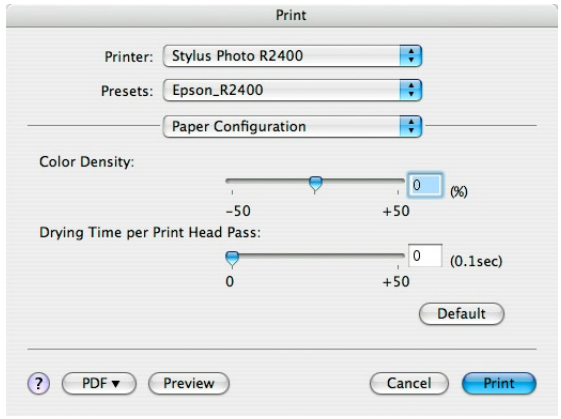
Color management
You may define how color management is done and by whom. If printing directly from Photoshop, turn color management off. If you print from a non-color-managed application, you should activate *ColorSync*.



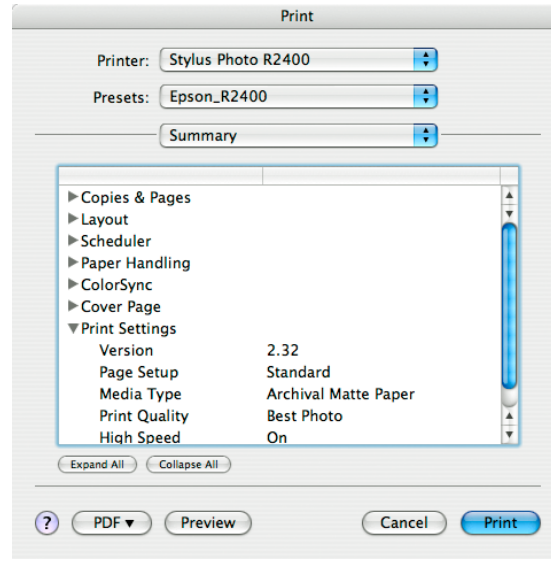
Extension Settings
is printer specific and only available for some printers. For the Epson R2400, for example, you may specify, using *Thick paper*.



Paper configuration
This item is only available with some printers (e. g. Epson R2400). You may reduce Color Density (actually ink density), which may prevent paper warping when printing on thinner paper.



Summary This can be very convenient, as all settings are summarized here and the individual details may be exposed or hidden by clicking on the small ▸ icon.



Save settings

After testing various settings and having discovered the proper settings for a printer and a specific type of print job, you should save those settings so you may recall them at a later time.
To save your settings, go to the menu item *Save As* under the drop-down-menu for Presets.

Give a descriptive setting name which states the type of paper and other important parameters. This name will then show up in the drop-down menu for Presets.

Printer maintenance utilities

As with MS Windows, you find printer maintenance utilities for inkjet printers. Here, however, you have to look in a different place for them. You will find them called *Printer Setup Utility* , which you will find in the dock.

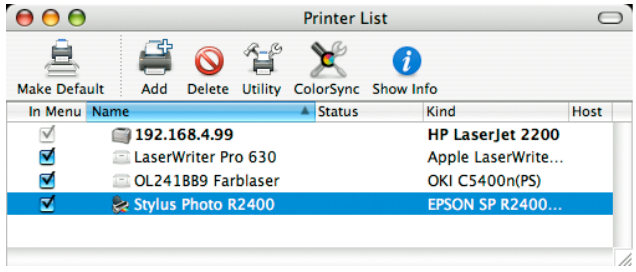


Figure 5-12: You may find the Mac OS X 'Printer Setup Utility' inside your Dock. It shows a list of all printers installed.

Here you should select your printer (we did it for our Epson Stylus Photo R2400), and click on *Utility* ( ). This – used with the Epson Inkjet printers – will bring up the Epson maintenance utilities:

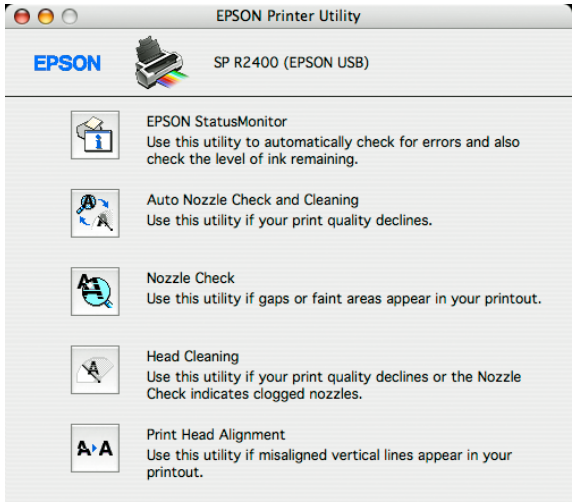

EPSON Printer Utility
EPSON
SP R2400 (EPSON USB)
EPSON StatusMonitor
Use this utility to automatically check for errors and also check the level of ink remaining.
Auto Nozzle Check and Cleaning
Use this utility if your print quality declines.
Nozzle Check
Use this utility if gaps or faint areas appear in your printout.
Head Cleaning
Use this utility if your print quality declines or the Nozzle Check indicates clogged nozzles.
Print Head Alignment
Use this utility if misaligned vertical lines appear in your printout.

Figure 5-13: From the 'printer Setup Utility' you may call up the 'Epson Printer Utility' which offers major maintenance functions.

Here, you find those maintenance functions already described at section 5-2.

Starting from the 'Printer Maintenance Utility' (see figure 5–12), you may also call up the Mac ColorSync Utility. (Click at). When Color Sync Utility comes up, select tab *Devices* (see figure 5-14). There, you may assign profiles to a device (here, a specific printer). This is useful if you print from a non-color-managed application and ColorSync must do the color-mapping.

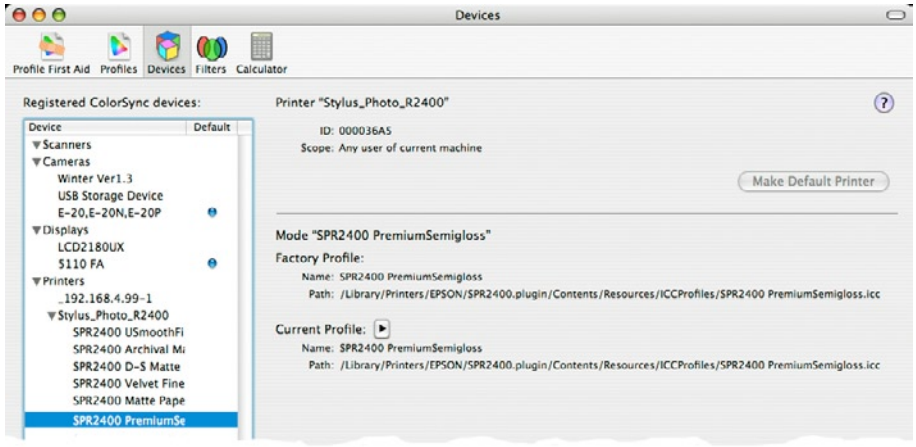


Figure 5-14: You should assign the appropriate profiles to your devices using the 'ColorSync Utility'. This helps when printing from a non-colored-managed application.

5.4 Printing from client software

Quality printing requires applications that are color management aware (such as Photoshop, ImagePrint, Qimage and many others). We describe printing from these applications only, as otherwise, achieving correct color can involve much trial and error. If you do not own any of these programs, we recommend keeping all your documents in an sRGB working space. You may be lucky and receive some decent prints.

We only cover printing from Photoshop CS2 here, but the principles are the same with all applications that are color management aware.

We use the Photoshop function Print with preview. Initially, Photoshop shows the following dialog:

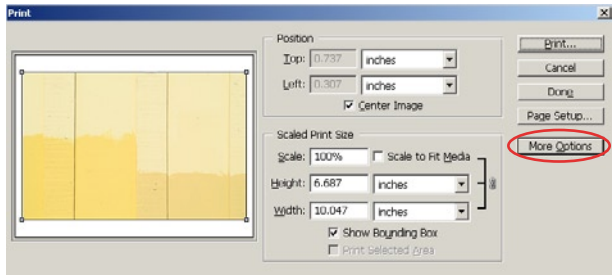


Figure 5-15: Photoshop basic print dialog

This dialog (figure 5-15) does not offer color management settings. This is why you should activate the advanced dialog by clicking button More Options.

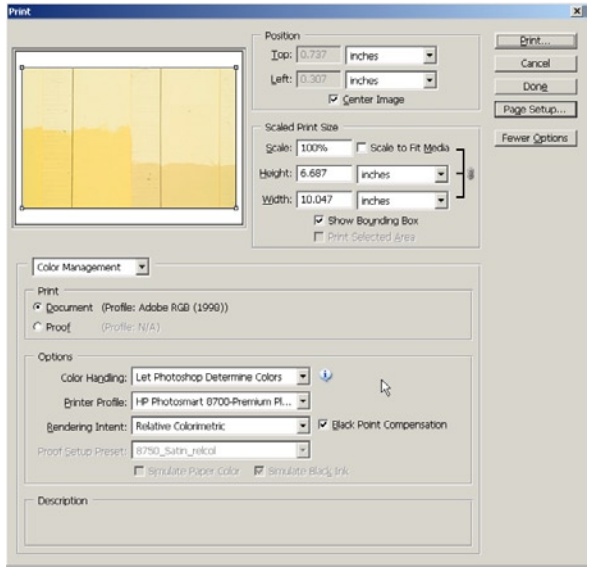


Figure 5-16: Photoshop advanced printing dialog

These are the recommend settings:

- Before changing any other settings, be certain you have the correct Page Setup:

  Here you will be able to define the paper size, the feeding option (paper source) and the page orientation. Before changing any of these parameters, select and setup your printer (click on the Printer button:

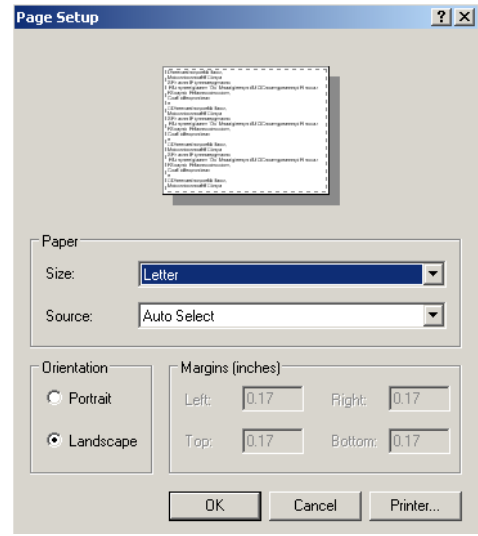


Figure 5-17: Page Setup

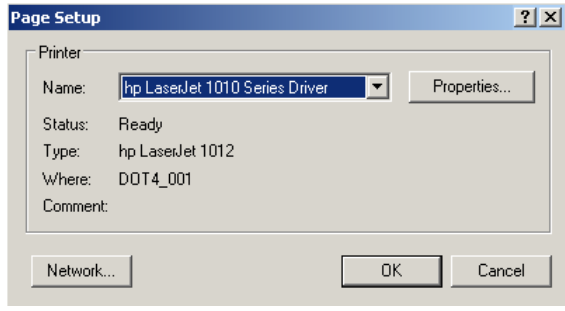


Figure 5-18: In Page Setup click Properties to more printer driver settings.

Once you have selected your printer, you must setup the correct printer driver options (click on Properties). These are the options we discussed earlier in the section on printer driver settings.

- You can change the size of the image. Normally, we do this in Photoshop before entering the printing dialog, because all this option does is to change the PPI of the document to match the new print size. This is fine for minor resizing, but in other situations, you are better advised to use the more advanced scaling techniques in Photoshop or perhaps a dedicated Photoshop plug-in.
- The drop-down box below the image preview is set to **Color Management.**

- We select the **Document Option** which shows our document's working space – here Adobe RGB (1998).
- Color handling allows selecting from 4 options:

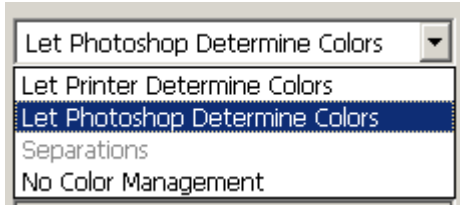


Figure 5-19:
Color Handling Options

  Normally, we would use *Let Photoshop Determine Colors*. This way, Photoshop controls the mapping of colors to the printer. There are situations where we may use different settings, and we cover that, too:

  – B&W printing

  – Printing of color targets to create printer profiles. Here we need to set Color Handling to *No Color Management*.

- In Printer Profile you select the correct (or best you can find) profile for your printer, paper, ink and other settings combination. As said before, good profiles make or break good prints. Currently, many printers come with adequate generic profiles to get you started.
- For **Rendering Intent** there are two choices:

  Perceptual: This is appropriate when your image has a lot of colors falling out of gamut (see Chapter 3.2, page 3-14 for that).

  Relative Colorimetric: Use this intent when colors in your image fit into the gamut of the printer color space. Check for this in Photoshop by activating gamut warning (⇧-Ctrl-Y Mac: ⇧-⌘-Y).
  No best rendering intent is suitable for all images. You need to experiment to learn which one fits best to your personal style. We personally nearly always print with the relative colorimetric rendering intent.

- Check the box **Black Point Compensation**. Rendering intents only define white point compensation. This feature by Adobe also compensates for a different level of black between the working color space and the printer color space.

5.5 Test prints

Now is a good time to perform a test print. Sometimes it is best to use special test images showing a variety of printer properties and limitations.

Bill Atkinson assembled such a test image, allowing us to share it with our readers:

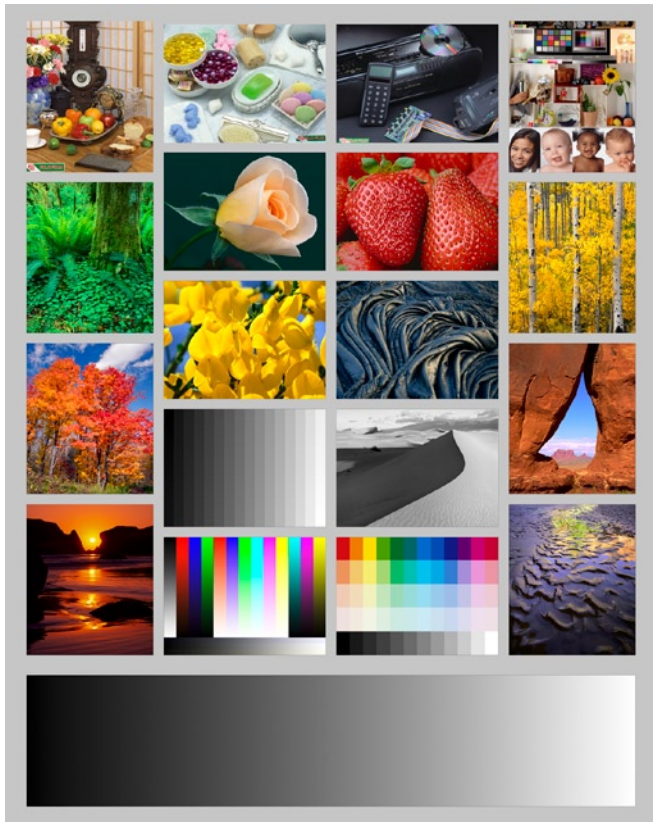


Figure 5-20: Test image, composed by Bill Atkinson. It may be downloaded from [34].

This is a LAB image (needs no working space) and can be downloaded from (24 MB ZIP file):

www.jirvana.com/resources/printing/bills_lab_test_image.zip

Resize the test image, if necessary, to fit your paper size.

Important checks:

- Possible casts in the gray ramps
- Handling of strongly saturated colors
- Skin tones
- Shadow details

5.6 Print quality related issues

In most cases, you are advised to continue working with your printer. Here is an additional short list of issues to be aware of.

Drying time Refrain from judging a print critically without giving it sufficient time to dry. A safe bet is about 1 day, but, for most prints 3–4 hours is enough. Likewise, never use prints in profiling without allowing enough drying time.

Prints from some printers (**e. g.** HP) are especially delicate immediately after printing. Make certain you don't touch the print surface, and let it dry in a place without excessive dust.

Inspecting your prints The inspection of your print should be done using standardized daylight – D50 (Daylight at 5 000 Kelvin), as all color management is based on this. How to obtain such light and for more details on image inspection and judgement, see Chapter 8 "Image Judgment".

Roller marks / pizza wheels Sometimes you may encounter roller marks on a printed paper's surface. There are many possible reasons. Check that paper settings and choice of paper are correct. Sometimes it is a good idea to consult printer specific news groups to learn tips from fellow users, even including possibly removing some printer wheels, with the advice of an experienced user.

Banding If you see banding, run a nozzle check and perform print head cleaning if necessary. The next step is to check head alignment and re-align the heads if needed. If this doesn't help, check your paper settings and turn off high speed. When not using standard paper, setting your printer to custom thickness settings, can be a way to avoid banding.

Dust spots Using some cotton papers, you occasionally see small spots after a print dries. This can be caused by cotton dust and/or scuffing. Here is how it happens: The paper has dust or other loose cotton on its surface. The the printer places ink on these areas. After printing, the particles fall off – and voilà, you get white spots. Always brush cotton based paper before feeding it into the printer.

Water spots Be careful not to get water on a picture. In many instances,, it is best to let it dry naturally. Trying to wipe it off can smudge the print and/or leave a mark.

5.7 Main fine art inkjet printers

We will discuss some of the most popular currently available fine art inkjet printers. The market leaders are (as of writing this book) Epson, HP and Canon. These companies each have their own inkjet technologies and produce printers with different features.

Epson Printers

Epson was the first of the companies to create a complete line of professional and semi-professional printers using only pigmented inks to allow for a better longevity. Here is a brief history on the Epson printers we have used:

Epson Stylus 2000P (13″ wide): First pigment ink printer on the market.

Epson Stylus Pro 7500 (24″) /9500 (44″): Professional printers using the same ink set as 2000P.

Epson Stylus 2100/2200 (13″): Introduced a new ink set called *UltraChrome*™ with 8 inks (the 2200 uses only 7 cartridges installed and the user can switch between Photo Black and Matte Black for printing on glossy or matte media, respectively).

Epson Stylus Pro 4000 (18″)/ **7600** (24″) / **9600** (44″): Professional printers using the same *UltraChrome* ink set as the 2200, although the 4000 can use all 8 inks installed simultaneously.

We cover the newer models introduced mainly in 2005. Epson has two major lines of ink sets:

- UltraChrome™ Hi-Gloss Ink (consumer printers, e.g. R800, R1800)
- UltraChrome™ K3 inks (professional and semi-professional market, e.g. R2400, R4800, R7800, R9800)

Printing with the Epson Stylus Photo R800/R1800

Figure 5-21:
Epson Stylus Photo R1800
(Courtesy of Epson America Inc.)

The inks

Both the R800 (letter sized prints) and the R1800 (13" wide, A3) feature the same ink sets – 8 Epson UltraChrome™ Hi-Gloss inks:

Gloss Optimizer, Photo Black, Matte Black
Cyan, Magenta, Yellow, Blue, Red

The R1800/R800 actually use only 6 true colors. The Photo Black and Matte Black are used for glossy and matte papers respectively. So, for a single print, only one is used.

Gloss Optimizer is not a true ink, rather, it controls colors. It is used to improve the glossy appearance of your print (producing less bronzing and gloss differential). Unless printing on very glossy media, you may not need the Gloss Optimizer at all. In any case, try your papers, both with and without Gloss Optimizer.

Note: Because R1800 and R800 only use a single black ink these printers are not an ideal choice for photographers who want excellent B&W prints with top neutrality. These printers may be able to produce some nice, casual B&W prints, in spite of it. The Epson R2400 or HP 8750 may be a better choice when excellent B&W prints are required.

Driver settings recommendations

What is covered here is not intended to replace your printer's manual. As usual, we assume you do all your color management inside the printing application (e.g. Photoshop).

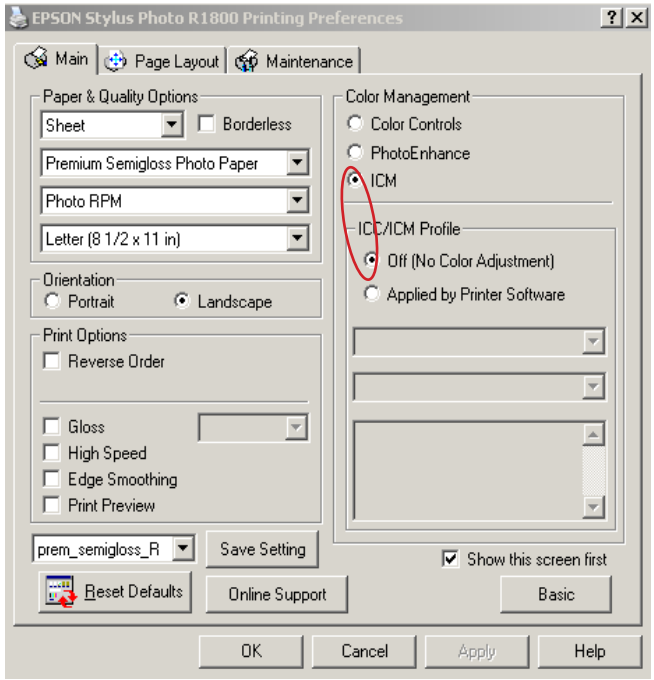
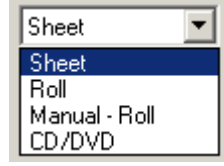
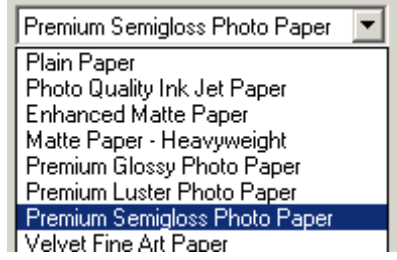


Fig. 5-22: Epson R1800: Main print driver dialog

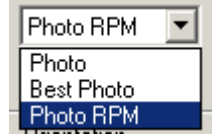
Paper selection ▸ Most users choose single sheet feeding with this printer (from the paper tray). When using roll stock, select it at this time.



Paper Type ▸ Here try to make a very close match.

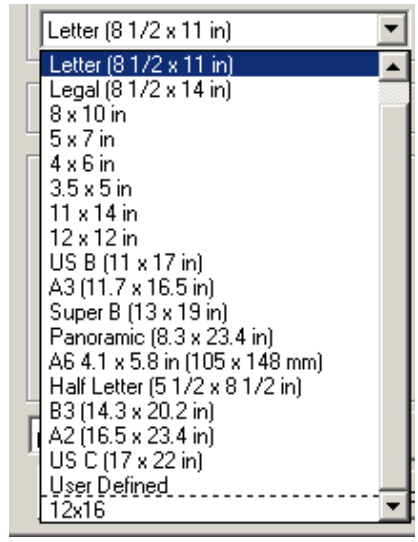


Print Quality ▸ The available quality settings will depend on the paper used. The highest quality setting is *Photo RPM*, and this selection often produces the best results at a price of speed and ink. Often, a lower quality setting may produce results close to maxi-



mum quality but requiring less ink and resulting in faster printing time.

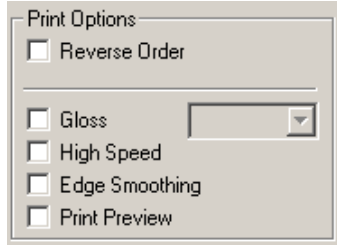
Paper Size ▸ Most often you will find your paper size listed. But, in some cases, you may also need to create a custom size. Select "User Defined." and follow the instructions.


Letter (8 1/2 x 11 in)
Letter (8 1/2 x 11 in)
Legal (8 1/2 x 14 in)
8 x 10 in
5 x 7 in
4 x 6 in
3.5 x 5 in
11 x 14 in
12 x 12 in
US B (11 x 17 in)
A3 (11.7 x 16.5 in)
Super B (13 x 19 in)
Panoramic (8.3 x 23.4 in)
A6 4.1 x 5.8 in (105 x 148 mm)
Half Letter (5 1/2 x 8 1/2 in)
B3 (14.3 x 20.2 in)
A2 (16.5 x 23.4 in)
US C (17 x 22 in)
User Defined
12x16

Orientation ▸ Choose whatever is needed: Landscape or Portrait mode.

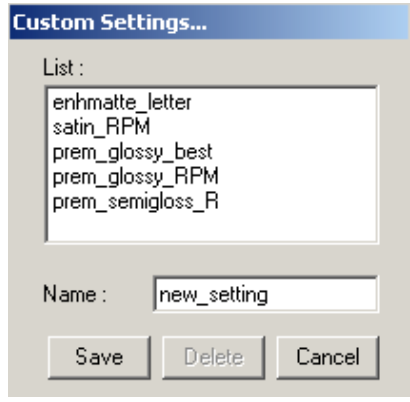
Print options

Gloss: Use only for highly glossy media
High Speed: Uncheck this option for best quality
Edge Smoothing: Off for fine art photos
Print Preview: We normally turn off. Be aware that preview colors may look incorrect (because they are not color managed).



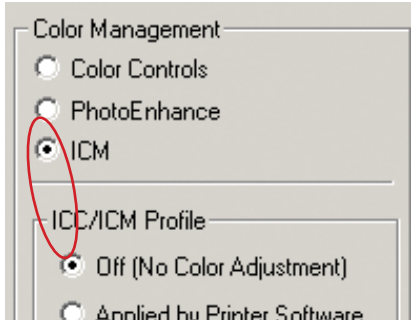
Saved Settings

In most printing, you use only a small number of different papers with few variations in their settings. Having found the proper settings for a certain type of print job and paper, you can save current settings and recall them later, much quicker. This practice also helps avoid costly mistakes (ink and paper are not inexpensive) .



Color management in the printer driver

With the R1800 and R800 we always turn printer CM off, and do the profile selection and color control inside Photoshop. The dialog of the printer driving settings shows exactly how.



Ink monitor

With Epson printers we print until we see an ink-low-warning. When you get this message, make sure you have a replacement ink cartridge available because the printer will soon be out of ink, and some printers stop all printing.

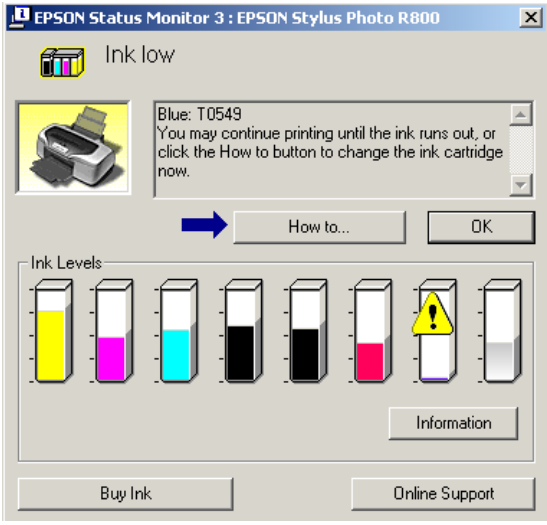

EPSON Status Monitor 3 : EPSON Stylus Photo R800
Ink low
Blue: T0549
You may continue printing until the ink runs out, or click the How to button to change the ink cartridge now.
How to...
OK
Ink Levels
Information
Buy Ink
Online Support

Figure 5-23: Ink-low-warning

Maintenance tools

Most printer sets include some maintenance tools. With most Epson printers, the maintenance application may be called from the printer driver interface. It offers some useful functions (see figure 5-13, page 5-16):

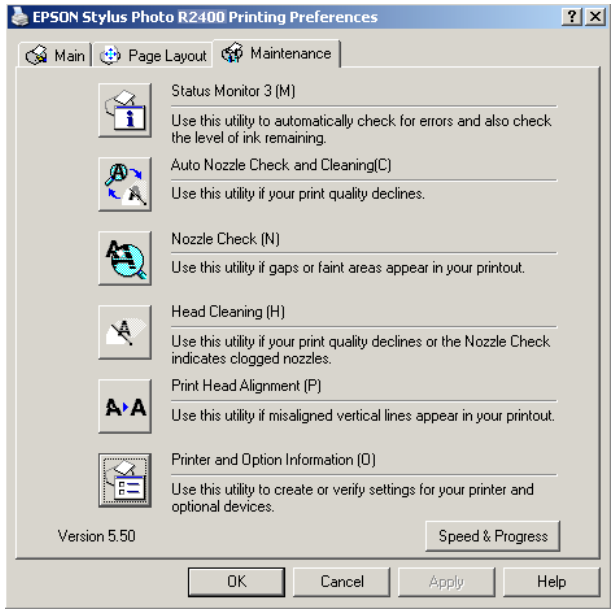

EPSON Stylus Photo R2400 Printing Preferences
Main
Page Layout
Maintenance
Status Monitor 3 (M)
Use this utility to automatically check for errors and also check the level of ink remaining.
Auto Nozzle Check and Cleaning(C)
Use this utility if your print quality declines.
Nozzle Check (N)
Use this utility if gaps or faint areas appear in your printout.
Head Cleaning (H)
Use this utility if your print quality declines or the Nozzle Check indicates clogged nozzles.
Print Head Alignment (P)
Use this utility if misaligned vertical lines appear in your printout.
Printer and Option Information (O)
Use this utility to create or verify settings for your printer and optional devices.
Version 5.50
Speed & Progress
OK
Cancel
Apply
Help

Figure 5-24: Maintenance tools called from the printer driver interface by selecting tab Maintenance.

Status Monitor: Shows the ink level dialog (see figure 5-23).

Nozzle Check and Cleaning: Check this when you have not used the printer for some days, if you see banding or some colors are missing. Be aware that this procedure consumes ink.

Nozzle Check (manual): Use it only when you have major issues.

Head Cleaning (manual): Use only when you have major issues. Be aware that using this procedure consumes ink.

Print Head Alignment: Perform when you see banding.

Printer and Option Information: We rarely use these options. Check your manual when you think you may need them.

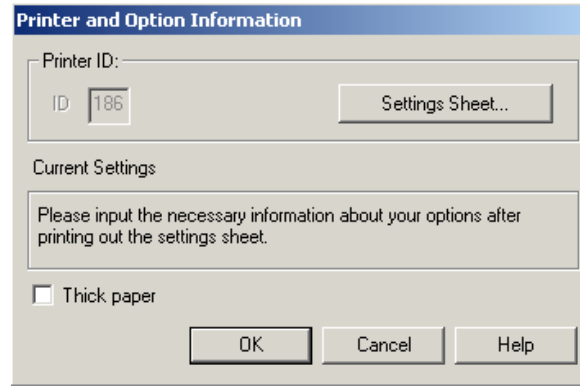


Figure 5-25: Printer information. Here, you may activate 'Thick paper'..

Manufacturer provided profiles for R800/R1800

Epson provides quite good generic profiles for their own papers. You can further improve color fidelity by using custom made ones. Most profiles come specifically targeted to certain print quality settings. Check that your choice of profile (in the client application e.g. Photoshop) matches your print quality settings (*Photo, Best Photo, Photo RPM*).

Note: With the R800, some profiles showed some "smudging." Check for more details in our R800 review [91], which is written in a diary style and which we update from time to time.

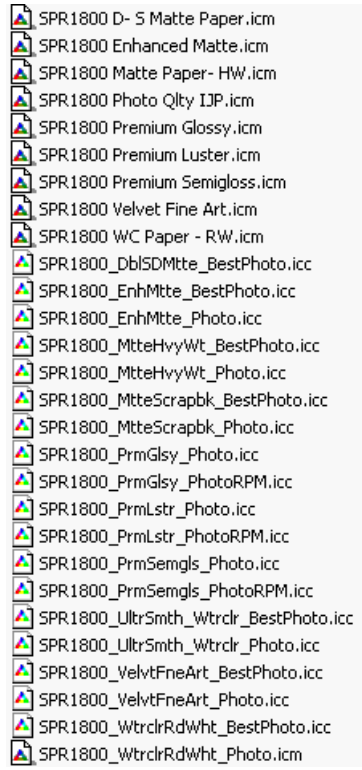


Figure 5-26: Profile provided by Epson for the R800/R1800

Epson Stylus Photo R2400 / Pro 4800 / 7800 / 9800

Figure 5–27:
Epson Stylus Photo R2400
(Courtesy of Epson America Inc.)

The Inks

All four printers feature the same ink set (Epson UltraChrome™ K3, 9 inks . This set is different from the R800/R1800:

Photo Black, Matte Black, Light Black, Light Light Black
Cyan, Light Cyan, Magenta, Light Magenta, Yellow

These printers actually use only 8 inks out of the 9 at simultaneously. Photo Black and Matte Black are used for glossy and matte papers, respectively. Unfortunately, to use them, it is required to switch between Matte and Photo Black ink when switching from matte to glossy media (this costs time and ink; and on the Pro printer line, it is a substantial amount of ink).

These printers do not use a Gloss Optimizer because the new ink formulas do not require it.

All four printers have three different blacks (Photo or Matte Black, Light Black and Light Light Black) allowing them to produce very good B&W prints with a highly neutral look and smooth gradients. We cover this in more detail in the B&W chapter.

Driver settings recommendations

As stated earlier, what is covered here is not a replacement for the printer manual. And as before, we assume you do all color management in your printing application (e.g. Photoshop). We show only

the settings of the R2400 as the same principles apply to the other more professional printers (Pro 4800, …, Pro 9800).

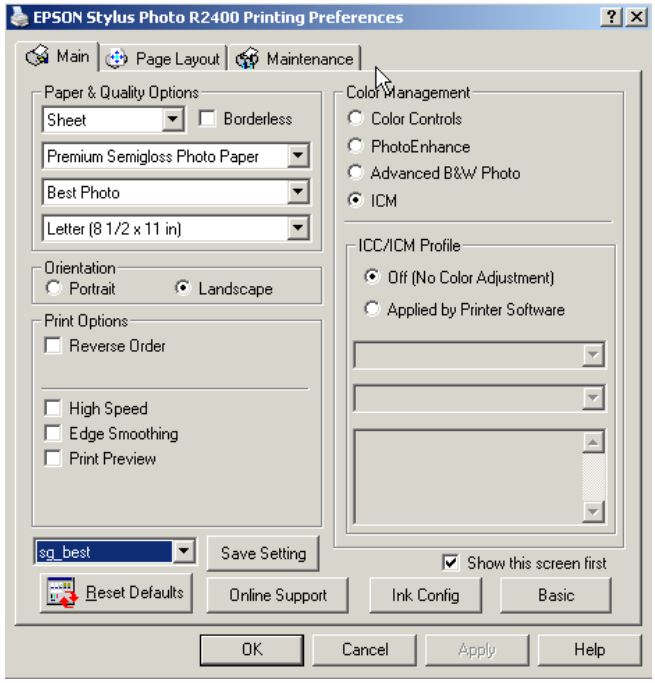
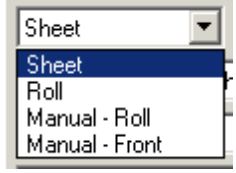
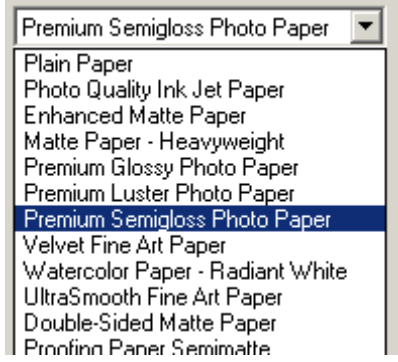


Figure 5-28: Driver settings recommended for fine art printing using the Epson R2400.

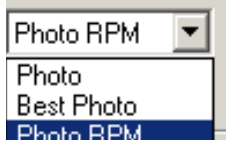
Paper selection Most users will print single sheets with this printer (from the paper tray), but the R2400 also comes with a roll feeder option out of the box.



Paper Type The list offered here is dependant on which Black ink is used in the printer (Photo Black or Matte Black). Here you must reach a very close match. Using a third party paper, you'll have to estimate which Epson paper is closest to the characteristics of your specific paper. You may have to do some experimenting using different paper type selections.

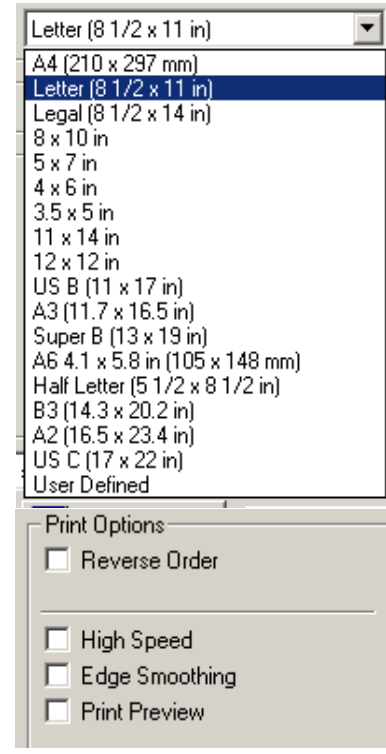


Print Quality The available quality settings depend on the paper type selected. The highest quality setting usually produces the best results



at the expense of speed and ink usage. A lower quality setting may produce a result close to maximum quality (e.g. *Best Photo* instead of *Photo RPM*).

Paper Size Most of the time you will find an appropriate paper size listed here. In rare cases, you may need to create a custom size. Just select and follow the instructions.


Letter (8 1/2 x 11 in)
A4 (210 x 297 mm)
Letter (8 1/2 x 11 in)
Legal (8 1/2 x 14 in)
8 x 10 in
5 x 7 in
4 x 6 in
3.5 x 5 in
11 x 14 in
12 x 12 in
US B (11 x 17 in)
A3 (11.7 x 16.5 in)
Super B (13 x 19 in)
A6 4.1 x 5.8 in (105 x 148 mm)
Half Letter (5 1/2 x 8 1/2 in)
B3 (14.3 x 20.2 in)
A2 (16.5 x 23.4 in)
US C (17 x 22 in)
User Defined
Print Options
Reverse Order
High Speed
Edge Smoothing
Print Preview

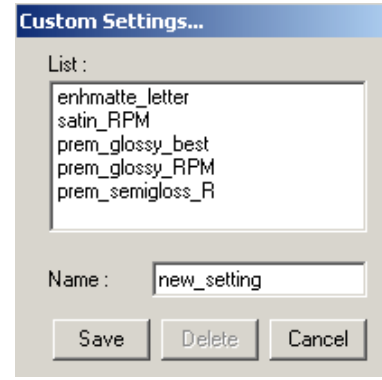
Orientation Choose whichever you need: Landscape or Portrait mode:

Print Options

- High Speed: Off for best quality
- Edge Smoothing: Off for fine art photos
- Print Preview: We usually turn it off. Be aware, that colors may appear untrue – This preview is not color managed.

Save your settings

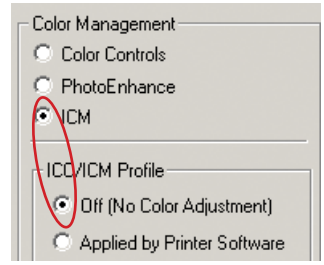
Because you likely use only a few different papers with few variations in their settings, having found the right settings for a certain type of print job and paper, save the settings and recall them later. It is much faster, and there is no danger you will forget to set all parameters correctly for this particular type of job.



Color Management

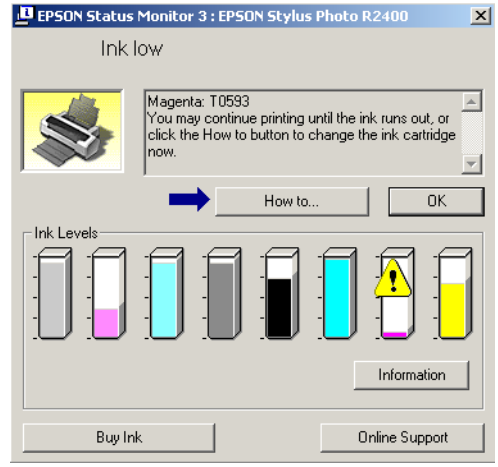
For the R1800 and R800 we turn printer CM off unless not printing B&W images or do profile selection and color control inside Photoshop. The dialog of the printer driver setting shows exactly how.

For B&W we would use the Advanced B&W Photo mode (which we describe in our B&W chapter).



Ink Monitor

When using Epson printers, print until the printer asks to replace an ink cartridge. When you get the Ink Low message, be sure you have a replacement ink cartridge available, as the printer will be out of ink soon and stops printing when exhausted.


EPSON Status Monitor 3 : EPSON Stylus Photo R2400
Ink low
Magenta: T0593
You may continue printing until the ink runs out, or click the How to button to change the ink cartridge now.
How to...
OK
Ink Levels
Information
Buy Ink
Online Support

Maintenance tools

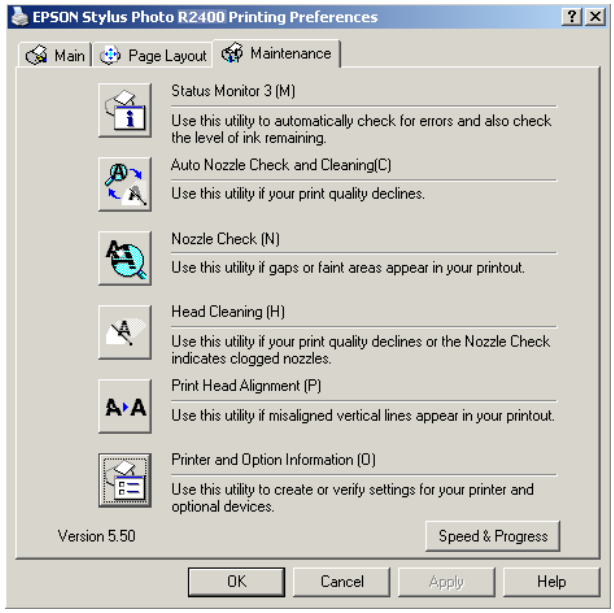

EPSON Stylus Photo R2400 Printing Preferences
Main
Page Layout
Maintenance
Status Monitor 3 (M)
Use this utility to automatically check for errors and also check the level of ink remaining.
Auto Nozzle Check and Cleaning(C)
Use this utility if your print quality declines.
Nozzle Check (N)
Use this utility if gaps or faint areas appear in your printout.
Head Cleaning (H)
Use this utility if your print quality declines or the Nozzle Check indicates clogged nozzles.
Print Head Alignment (P)
Use this utility if misaligned vertical lines appear in your printout.
Printer and Option Information (O)
Use this utility to create or verify settings for your printer and optional devices.
Version 5.50
Speed & Progress
OK
Cancel
Apply
Help

Figure 5-29: Maintenance tools of the R2400, called up form the printer driver dialog

Status Monitor: Shows the ink level dialog

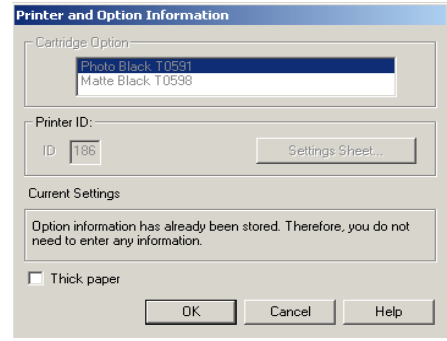
Nozzle Check and Cleaning: Check when you have not used the printer for some days, or if you see banding or some colors are missing. Be aware that this procedure consumes ink.

Nozzle Check (manual): Only use it if you have major issues.

Head Cleaning (manual): Only use it if you have major issues. Be aware that this procedure consumes ink.

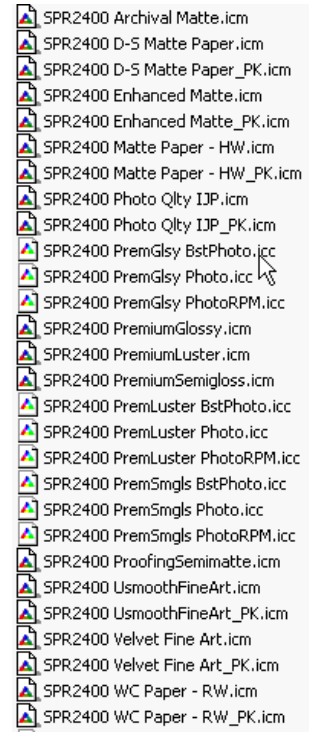
Print Head Alignment: Check this if you see banding.

Printer and Option Information: This is the dialog used to indicate which black is currently loaded. Be sure it shows the black that actually is loaded into the printer, because the driver depends on this information to work optimally.



Manufacturer provided profiles for R2400

Epson provides good generic profiles, but only for their own papers. You may further improve color fidelity by using custom made ones. Most profiles come specifically targeted to certain print quality settings. Check that your choice of profile (in the client application **e.g. Photoshop**) matches the print quality settings done in the print driver dialog (*Photo, Best Photo, Photo RPM*).



Some help for paper feeding

With the R2400 we have encountered some problems when sheet paper feeding. If this happens, it may helpful to apply slight pressure with a finger at the top of the sheet.

HP printers

While Epson printers use mainly pigmented inks to improve longevity, HP printers featured here use dye based inks to improve longevity with optimal paper-ink combinations. The prints using the printers we cover using HP Premium Photo Plus papers are rated at about 80 years by Wilhelm Imaging Research (WIR, [60]).

Newer models we feature were introduced mainly in 2005. These are the main models for fine art prints

- HP Photosmart 8450 & 8750
- Designjet 30 / 90 / 130

HP Photosmart 8450/ 8750

Figure 5-30:
HP Photosmart 8750
(Courtesy of HP)

Both, the 8450 (letter sized prints) and the 8750 (13" wide, A3+), feature the same ink set. HP introduced the first true B & W printers featuring three blacks, and the 8750 was the first A3 using these inks. Shortly after, Epson followed up with its new UltraChrome™ K3 printers.

The Inks

HP calls its archival dye inks *Vivera inks*. The 8750 can take three cartridges with up to three inks in each cartridge.

- HP 97 Tri-color (3 colors) always needed
- HP 99 Photo (3 colors), needed for fine art prints with the 8450, but the 8750 may work better with the 102 cartridge (see below)
- HP 96 Black (1 black). This is OK for color prints, but should be replaced by a Gray Photo cartridge (HP 100/102) when you print B&W.
- HP 100/102 Gray Photo (3 gray/black at 15/23 ml) for excellent B&W images
- HP 102 Blue Photo (to enhance blue color gamut). Only used in the 8750.

Driver settings recommendations

What we cover here is not intended as a replacement for the printer manual. We assume you do all color management inside the printing application (e.g. Photoshop).

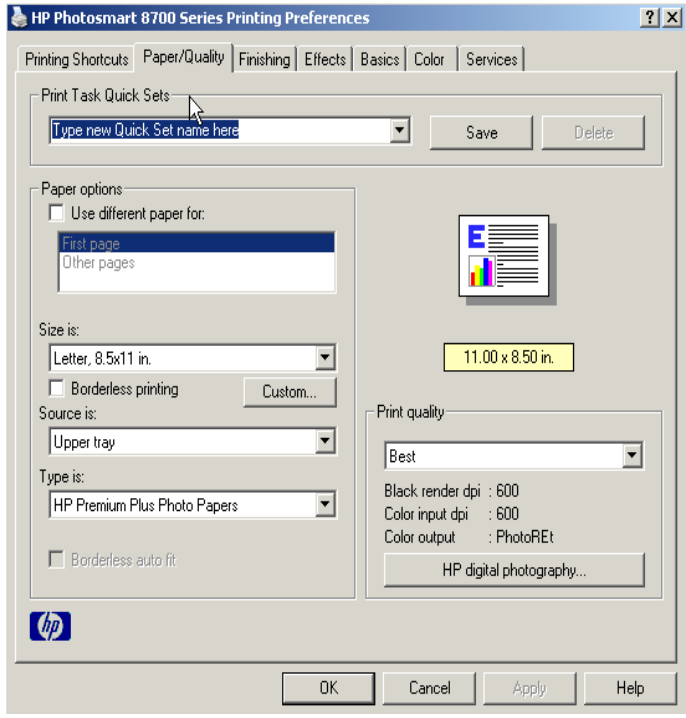
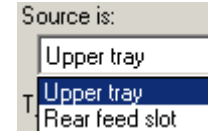
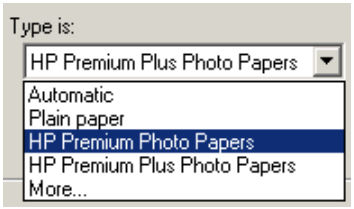


Figure 5-31: 8750 Paper dialog

Paper selection (feed) Most users use single sheets with this printer (from the paper tray).



Paper Type Try for a very close match. Prints with non-matching paper type setting can be highly inaccurate.



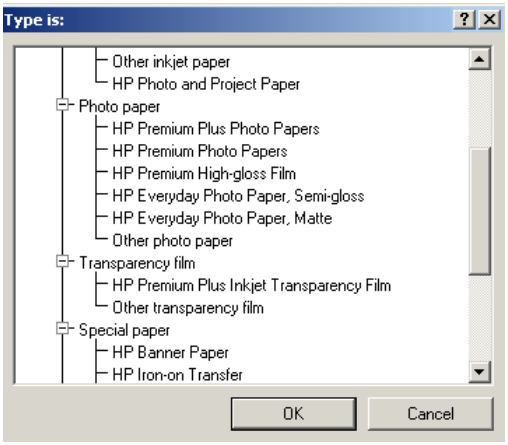
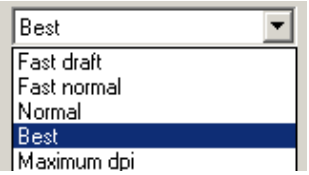
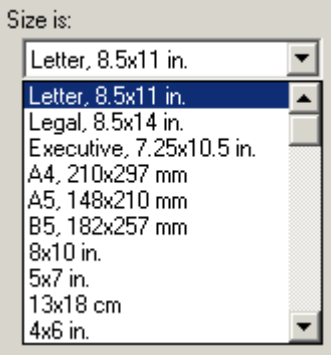


Figure 5-32: Paper selection

Print Quality Available quality settings depend on the paper used. The highest quality setting produce the best results at the expense of speed and ink usage. Sometimes a lower quality setting produces results close to maximum. We use HP printers only at the setting *Best*.



Paper Size Most often, you will find your paper size listed. In some cases, you may need to create a custom paper size. Select *User Defined* and follow the instructions.

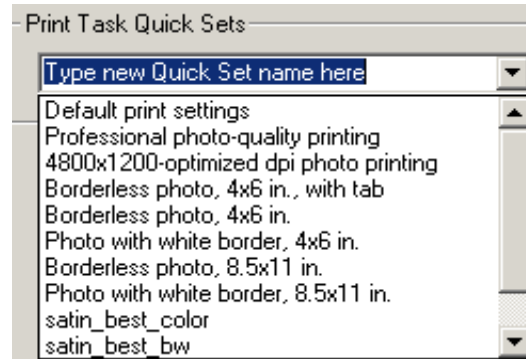


Orientation (found on the Basics tab) Choose whichever you need: Landscape or Portrait mode.

Print Options Print Preview: We leave it off usually.

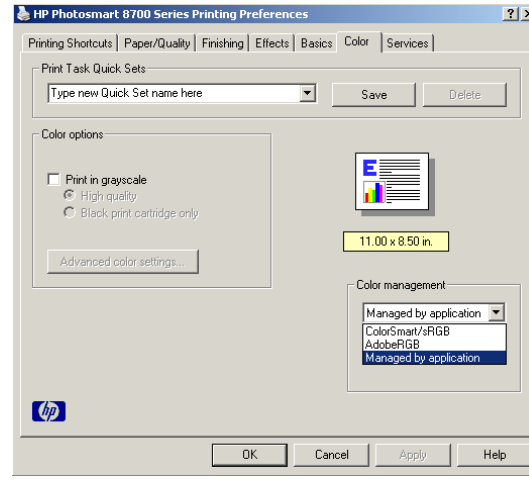
Saved Settings

In most cases, you will use but a few papers with few variations in settings. Save settings and recall them later. Both saves time and also avoids costly errors (ink and paper are not inexpensive).


Print Task Quick Sets
Type new Quick Set name here
Default print settings
Professional photo-quality printing
4800x1200-optimized dpi photo printing
Borderless photo, 4x6 in., with tab
Borderless photo, 4x6 in.
Photo with white border, 4x6 in.
Borderless photo, 8.5x11 in.
Photo with white border, 8.5x11 in.
satin_best_color
satin_best_bw

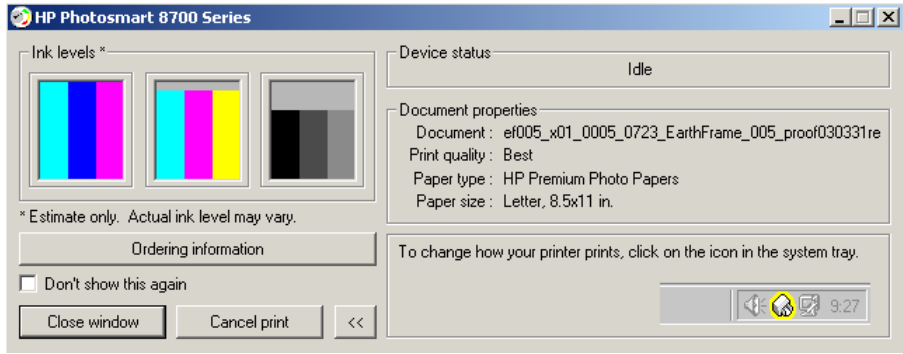
Color Management

For the 8750/8450 we always turn printer CM off. The driver is then set to *Managed by Application*. The only exception is printing B&W on the 8750 / 8450 printers (see our B & W chapter 7).



Ink Monitor

With HP printers, you cannot continue printing until the machine stops. We might try to squeeze 3 to 5 prints out of the cartridge, and then replace ink, but when you get an *Ink Low* message, be sure you have a replacement ink cartridge available. The printer will be out of that ink soon.



Maintenance tools

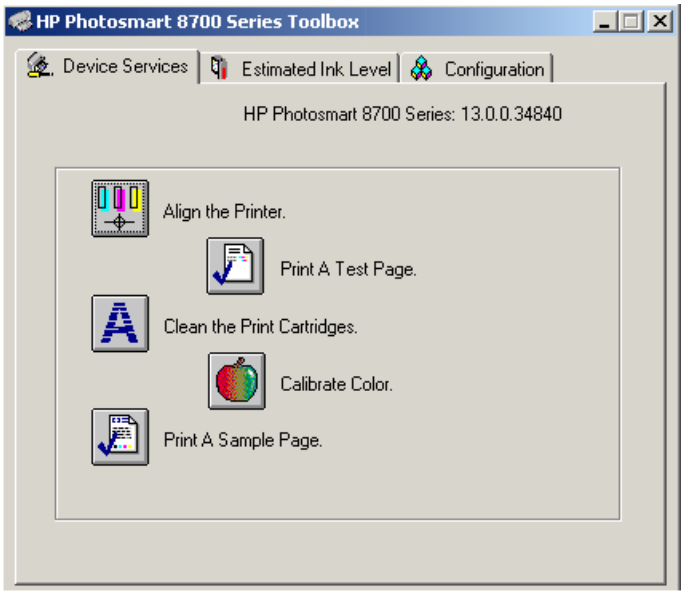


Figure 5-33: Maintenance tools with the HP 8700

Align the Printer: Check if you see banding.

Clean the Print Cartridges: Advised to be used also if you encounter banding in prints

Calibrate Color: As we understand it, the printer does an automatic calibration when you replace cartridges (which includes the heads).

Printer and Option Information: We rarely use these options. Check your manual as to when you may need them. You may reduce the amount of ink laid down on a paper when using thinner paper having a tendency to warp. So far, we have not experienced that.

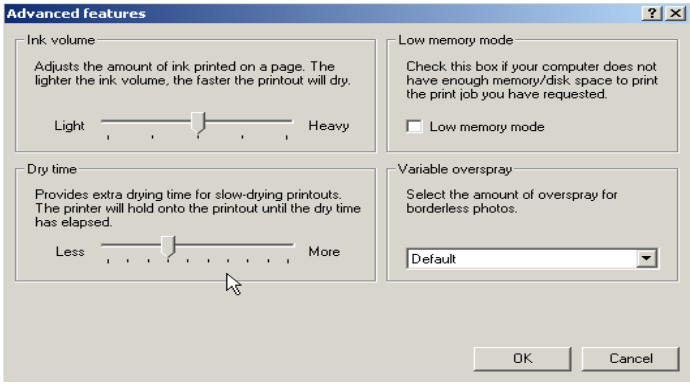

Advanced features
Ink volume
Adjusts the amount of ink printed on a page. The lighter the ink volume, the faster the printout will dry.
Light
Heavy
Low memory mode
Check this box if your computer does not have enough memory/disk space to print the print job you have requested.
Low memory mode
Dry time
Provides extra drying time for slow-drying printouts. The printer will hold onto the printout until the dry time has elapsed.
Less
More
Variable overspray
Select the amount of overspray for borderless photos.
Default
OK
Cancel

Figure 5-34: Here, you may reduce the amount of ink laid down on paper.

Manufacturer-provided profiles for 8750

HP provides good quality generic profiles for their own papers. You may improve prints by using custom made ones. Most profiles come specifically targeted to certain print quality settings. Check that your choice of profile (in the client application e.g. Photoshop) not only matches the paper type, but also print quality settings.

Figure 5-35: List of generic profiles provided by HP for the Photosmart 8400.

HP Designjet 30 / 90 /130

These Designjet printers are affordable, professional printers that can print 13", 18" and 24" wide respectively.

Figure 5-36: HP Designjet 90 (Courtesy HP America)

The inks

HP archival dye inks, *Vivera inks,* are use by the Designjet 30 / 90 / 130 printers, each using the same ink cartridges and ink sets.

They are: Black, Cyan, Magenta, Yellow, Light Cyan and Light Magenta

Overall, the cost per print is notably lower than with the Photosmart 8750 or 9450 printers due to the much larger capacity of the ink cartridges.

Note: Because these printers use only one type of black ink, they are not an optimal choice for photographers wanting excellent B&W prints with top neutrality. However, these printers may be used to produce some very acceptable B & W prints. Epson K3 or HP 8750 printers may be a better choice when superior B&W prints are your goal.

Driver settings recommendations

Stated once again, what is covered here should not be viewed as a replacement for the printer manual. And, as usual, we assume that you do all color management in the print application, such as Photoshop. We cover the latest model Designjet 90 here. The previous one works similarly.

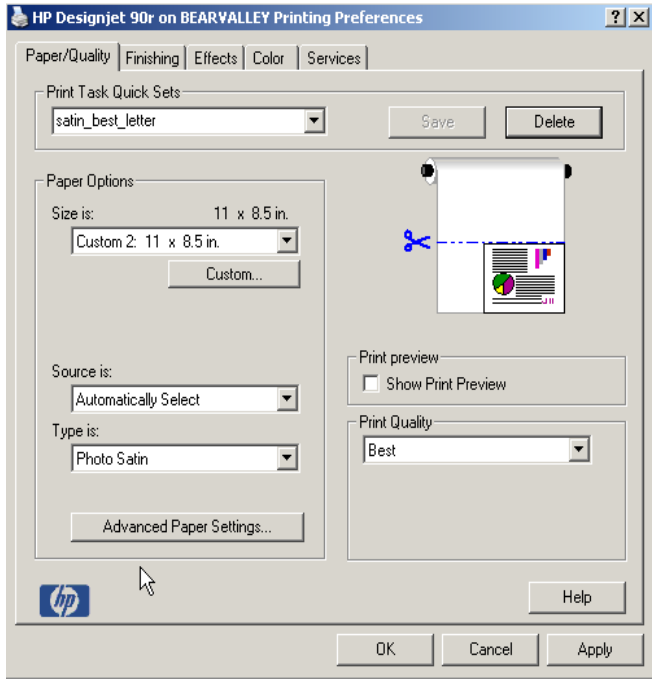
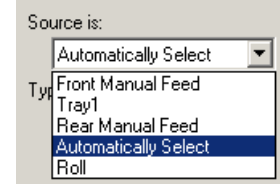
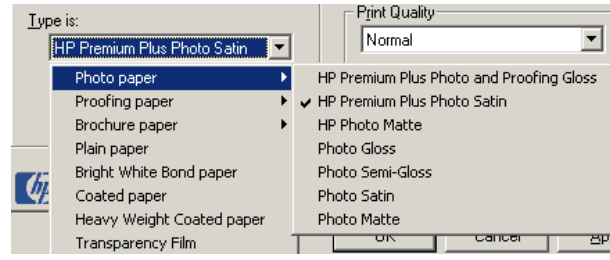


Figure 5-37: Designjet 90 Paper dialog

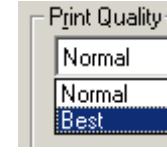
Paper selection (feed) Most users prefer single sheet feeding with this printer (from the paper tray). We do not recommend using *Automatically Select,* as the printer occasionally does not recognize the correct paper automatically.



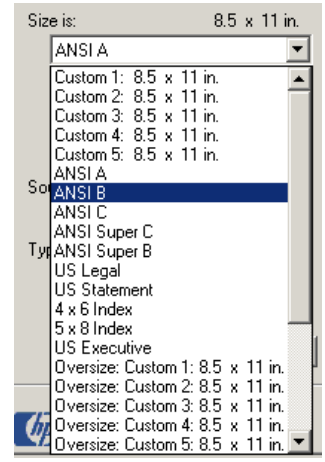
Paper Type
Achieve exact or very close match. Incorrect paper type setting can cause serious print discrepancies.



Print Quality The available quality settings depend on the paper used. The highest quality setting will often produce the best results at the expense of speed and ink usage. A lower quality setting may produce results very close to maximum quality. We prefer using HP printers only at their *Best* setting.



Paper Size You will usually find your paper size listed. But, in some cases, you may need to create a custom size. Just select *User Defined* and follow the instructions.


Size is:
8.5 x 11 in.
ANSI A
Custom 1: 8.5 x 11 in.
Custom 2: 8.5 x 11 in.
Custom 3: 8.5 x 11 in.
Custom 4: 8.5 x 11 in.
Custom 5: 8.5 x 11 in.
ANSI A
ANSI B
ANSI C
ANSI Super C
ANSI Super B
US Legal
US Statement
4 x 6 Index
5 x 8 Index
US Executive
Oversize: Custom 1: 8.5 x 11 in.
Oversize: Custom 2: 8.5 x 11 in.
Oversize: Custom 3: 8.5 x 11 in.
Oversize: Custom 4: 8.5 x 11 in.
Oversize: Custom 5: 8.5 x 11 in.

Orientation (found on the Finishing tab): Choose whichever you need: Landscape or Portrait mode.

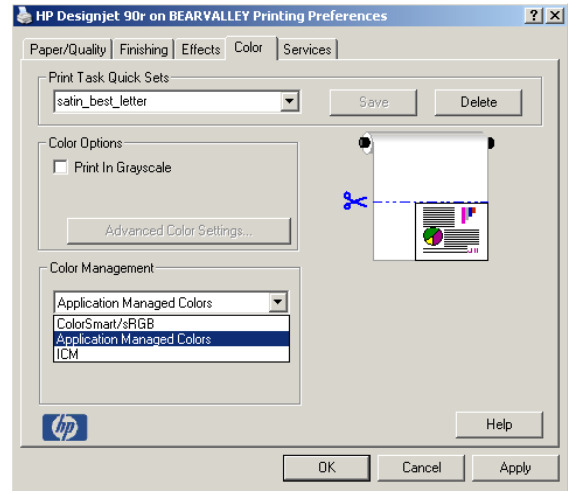
Print Options Print Preview: We choose to keep it normally, off.

Saved Settings

Most fine art printers use only a few different papers with slight variations in their settings. You may save the settings and recall them later quite easily, avoiding costly mistakes (ink and paper can be expensive).

Color Management

For the Designjet 90, we always turn printer CM off. This sets the driver to *Application Managed Colors*. The only exception is printing B&W (see our B&W chapter).



Ink Level Monitor

The Designjet 90 has an LCD panel which continually shows the levels of all 6 inks. When you get an *Ink Low* message, be sure you have a replacement ink cartridge available. The printer will be out of ink soon.

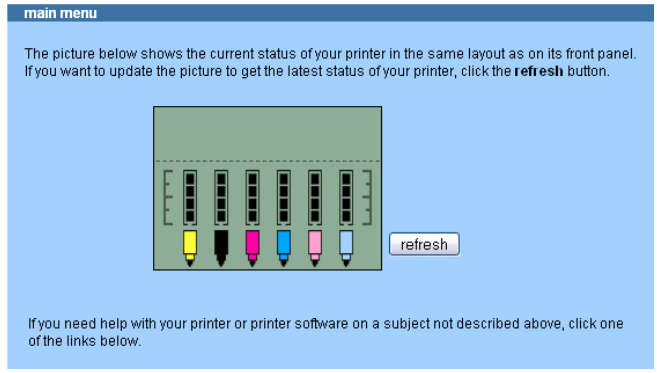
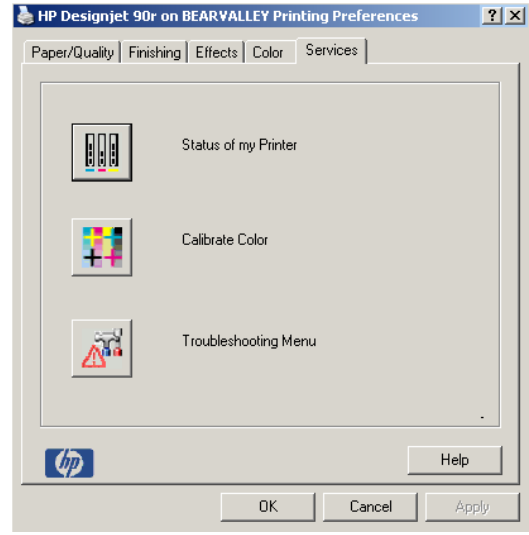

main menu
The picture below shows the current status of your printer in the same layout as on its front panel.
If you want to update the picture to get the latest status of your printer, click the refresh button.
refresh
If you need help with your printer or printer software on a subject not described above, click one of the links below.

Figure 5-39: Designjet 90 LCD panel continually shows the fill levels of your inks.

Maintenance tools



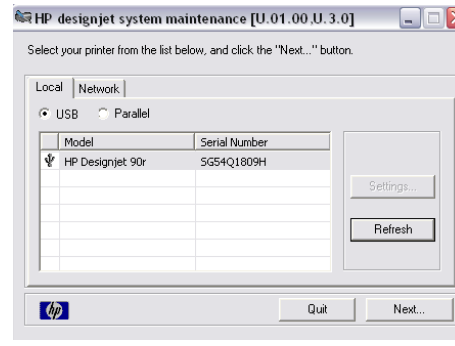
When you call up a maintenance utility, a web page is called up.

Note: Use MS Internet Explorer as your default browser. Do not connect the printer through a hub (though some may work).

Status of the printer: Shows the printer status.

Calibrate Color: **This needs to be done** for all paper types, and also must be redone after switching inks or heads.

HP uses, for their color calibration, a browser interface that assumes on some PCs that Internet Explorer is the default browser. Also, for maintenance, connect the printer directly to a USB port on your PC, as it may not work properly with some USB hubs. Then locate the printer used with the dialog shown here:



Click on Next, and the browser will be launched with the maintenance page. Select calibrate color:

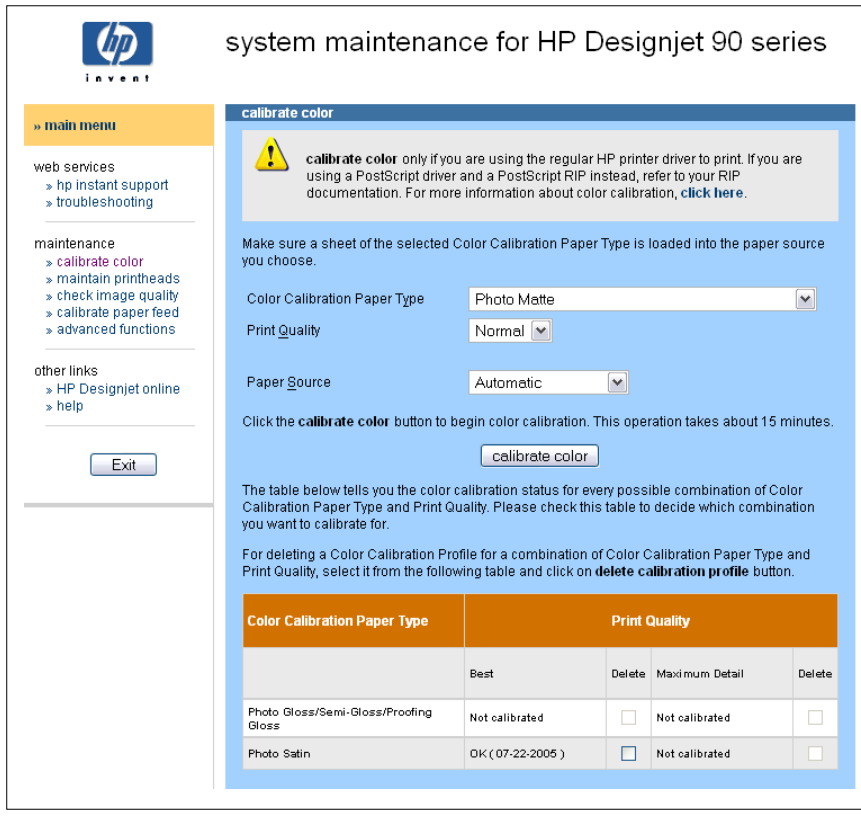
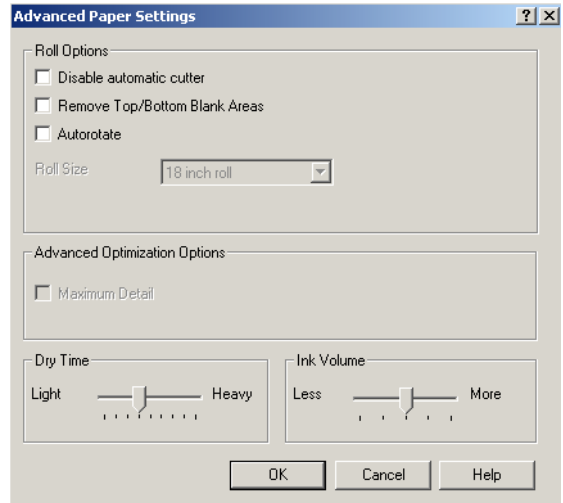

system maintenance for HP Designjet 90 series
» main menu
web services
» hp instant support
» troubleshooting
maintenance
» calibrate color
» maintain printheads
» check image quality
» calibrate paper feed
» advanced functions
other links
» HP Designjet online
» help
Exit
calibrate color
calibrate color only if you are using the regular HP printer driver to print. If you are using a PostScript driver and a PostScript RIP instead, refer to your RIP documentation. For more information about color calibration, click here.
Make sure a sheet of the selected Color Calibration Paper Type is loaded into the paper source you choose.
Color Calibration Paper Type
Photo Matte
Print Quality
Normal
Paper Source
Automatic
Click the calibrate color button to begin color calibration. This operation takes about 15 minutes.
calibrate color
The table below tells you the color calibration status for every possible combination of Color Calibration Paper Type and Print Quality. Please check this table to decide which combination you want to calibrate for.
For deleting a Color Calibration Profile for a combination of Color Calibration Paper Type and Print Quality, select it from the following table and click on delete calibration profile button.
Color Calibration Paper Type
Print Quality
Best
Delete
Maximum Detail
Delete
Photo Gloss/Semi-Gloss/Proofing Gloss
Not calibrated
Not calibrated
Photo Satin
OK (07-22-2005)
Not calibrated

Figure 5-39: Dialog for color calibration

The page shows which paper you have calibrated and when. Actually, this is not true color calibration. The printer does, however, measure ink density for each print-head (for each color) and adjusts accordingly. For this purpose, an ink pattern is printed.

Printer and Option Information

We rarely use these options. Check your manual as to when you may need them.



Manufacturer provided profiles for DJ 90

HP has provided good generic profiles for their own papers. Color fidelity may be further improved by using custom made ones. Most profiles are specifically targeted to certain print quality settings. Check that your choice of profile (in the client application e.g. Photoshop) matches your print quality settings.

HP DJ 30/90/130 - Brochure Gloss - Drv
HP DJ 30/90/130 - Brochure Matte - Drv
HP DJ 30/90/130 - Coated - Drv
HP DJ 30/90/130 - Heavy Coated - Drv
HP DJ 30/90/130 - Photo Gloss - Drv
HP DJ 30/90/130 - Photo Gloss - Max Detail - Drv
HP DJ 30/90/130 - Photo Matte - Drv
HP DJ 30/90/130 - Photo Satin - Drv
HP DJ 30/90/130 - Photo Satin - Max Detail - Drv
HP DJ 30/90/130 - Photo Semi-Gloss - Drv
HP DJ 30/90/130 - Photo Semi-Gloss - Max Detail - Dr
HP DJ 30/90/130 - Plain Paper - Drv
HP DJ 30/90/130 - Proofing Gloss - Drv
HP DJ 30/90/130 - Proofing Gloss - Max Detail - Drv
HP DJ 30/90/130 - Proofing Matte - Drv
HP DJ 30/90/130 - Proofing Semi-Gloss - Drv
HP DJ 30/90/130 - Transparency - Drv

Figure 5-40: Manufacturer-supplied profiles for the Designjet 90

5.8 Some recommendations for printing

Though we already mentioned some of the follow recommendations, we want to repeat some of them here:

- **Print regularly**
  Inkjet inks tend to dry up fast and may clog up the nozzles of your print heads. For this reason, you should use your ink jet printers regularly – even if you actually have no need for a print. Once a week is a good time frame, once every fortnight should be minimum. With Epson printers, the danger of nozzle clogging is worse than with HP or Canon printers – obviously due to the pigmented inks. If you really have no inkjet print to do, simply run a nozzle cleaning circle with your printer.

- **Check your inks and run a nuzzle check before you start a large print.**
  It is annoying if you spoil an expensive sheet of paper due to clogged nozzles or because there is not enough inks to complete your print. For this reason, it is well worth checking your inks (all of the printer we discuss here will show the status of all the inks). If you have plenty of ink for your print and have not printed for some days, run a nozzle check (usually offered as part of the printers maintenance utility (see page 5-15 and page 5-27 for the Epson maintenance tools or page 5-38 for the HP tools) to make sure, that your nozzles are no clogged. Nozzle clogging may show as via banding, color shifts or stripes in the print.

- **Clean up your paper before the print.**
  Often, ink jet papers come with some paper dust on it. Therefore you should clean the paper before inserting it into the printer. You may use a soft, large cosmetic brush (not used otherwise) for the cleaning or a small, soft broom.

  This prevents the dust from clogging your print heads or your printers rollers. It is also very annoying, if tiny paper fragments stick to the paper when the print is done and fall off afterwards, exposing plain paper spots with no ink.

  Some paper are more susceptible to this problems than others. We had some experiences with this phenomenon with Hahnemuehle papers (e. g. PhotoRag).

- **Give your prints ample time for drying before touching and framing.**
  Actually, you should never touch the printed area of your prints – at least not with your bare hands. Better ware cotton gloves when handling your prints or sensible papers.
  Avoid stacking your prints before they are dried up thoroughly.
- **Cover up your printer when not in use.**
  Cover up your printer with a dust cover in order to prevent dust and other dirt entering your printer.
- **Keep your spare inks cool.**
- **Keep your spare paper dark, dry and cool and store it even and horizontal.**
- **Make sure, your printer is correctly setup for your paper.**
  With some printers, you have to specially set up your printer if you use thick paper. You may have to set this either in your printer driver or you may have to use a lever at the printer or you may have to use a special paper feed
- **Make sure, you use the proper profile for your paper and your printer settings.**
  As stated when describing how to produce a printer profile, the profile is specific not only to the printer, the inks used and the paper used, but also to the printer settings. Printer settings – e.g. print quality settings – should be reflected in the profile names. Make sure, that you select a printer profile, that closely corresponds your settings in the printer driver.

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Chapter 6

Printing Packages and RIPs

Camera: Canon 1DsX

You may achieve excellent prints when printing from Photoshop or another color-managed application using the standard printer driver of your operating system. In most cases, this printer driver is actually supplied by the printer manufacturer. The process for doing this is described in Chapter 5.4 to Chapter 5.8.

In some cases, however, you may need more help – **e. g. when** you not only want to print a single image, but a DTP-built page with text, raster images and line-art graphics. In other situations, you may look for greater control over printing settings than the standard printer driver provides, or you may want to use fine art papers the driver does not support. Then, a RIP – a *Raster Image Processor* may help.

6.1 What is a RIP?

A RIP – or *Raster Image Processor* – takes the input and produces a raster image from it, a raster pattern, suitable as direct input for a printer. It does all the color conversion – e. g. from RGB to the printer's primary colors (which, in photo inkjet printers are usually 6–9 different colored inks) – it does the dithering, the resolution adaptation required and more. It's what a standard printer driver does, and usually more – e. g. supports standard ICC profiles. Basically there are two types of RIPs:

- RIPs that only do rasterization of the input
- RIPs that do additional print-language translation – e. g. from PostScript to an internal printer language

For fine art printing, the first type of RIP is good enough, in most cases – and is often considerably cheaper. PostScript-enabled RIPs make sense when you intend to use the RIP for contract press-proofing. Using a PostScript printer, the second kind of RIP is already integrated into your printer's hardware, this integrated RIP, however, may not provide all the features and controls offered with separate RIPs.

Most RIPs are *optional equipment* – implying you must pay extra for them. Both, HP, as well as, Epson offer separate software RIPs for (some of) their inkjet printers (HP, meanwhile, discontinued its Software-based RIP and replaced it with an 'EFI Designer-Edition RIP,' described in section 6.3). There are many other RIPs offered by third-party companies, and frequently they are cheaper, more universal and even offer better quality or flexibility for a particular task, such as Black&White printing.

Why use a RIP?

Above, we have listed the main reasons for using a separate RIP:

- More control over printing parameters
- Support of high-level printer languages (often PostScript or PDF)

But there are some other useful features a RIP may provide:

- Smoother workflow than printer drivers (e. g. network-printing, hot-folders, different job queues for different job types)
- Better dithering and/or up-sizing algorithms

- More control of ink lay-down
- Additional ICC profiles for some fine art printers, third-party inks or press printing
- Support for profiling
- Support for special third-party inks (often for B&W printing)
- Optimized placement of several images on the same page
- Special features for Black&White printing (e.g. special B&W profiles for printing, as well as, soft-proofing)
- Special features for CMYK proofs (contract press-proofs)

Not all of these features are provided by all RIPs, and not all features may be needed. For this reason, there is no single solution for all users. However, we will describe some RIPs we've used and features of them we found useful for our kind of work.

6.2 Printing using a printing package

When direct printing with the printer manufacturer's printer driver is not good quite enough, but a RIP is too expensive (there are some moderately priced RIPs), a printing package may be the answer. These are stand-alone applications helping to prepare an image for printing by calling up a printer driver and passing the image along for printing. They do no actual dithering (also called *screening*) that a RIP or a printer driver can do.

Nevertheless, they may be helpful, e.g. doing printer-specific up- or down-sizing of an image and even do some sharpening. They also may replace Photoshop as the printing-application and do color management (not leaving it to the driver). These packages sometimes come with additional profiles or aid in creating printer profiles. Image placement (several images on a single output page) is another feature of this kind of software. While we rarely use them for fine art prints, they may be useful for test prints or for contact sheets.

Often, these utilities offer additional image enhancement operations, but, as a rule, we don't use these features, as, according to our experience, good RAW converters plus Photoshop are usually superior. Qimage is one such printing utility. There are other printing packages, but we have little or no experience with them.

Qimage

Qimage by Digital Domain Inc. [31] is a low-priced (about 50 $ US for Qimage Pro) image printing package for Windows. It includes free lifetime updates/upgrades. There is a Pro and a Lite version of Qimage. According to our experience, Qimage Lite (39 $ US) will provide, in most cases, for our kind of usage, but the price tag for even the Pro version is reasonable. While no native Mac version is available, Qimage may be run with VPC (a PC emulator on a Mac). Here is a list of features in Qimage we consider useful:

- Supports a very broad range of inkjet printer from HP, Epson and Canon
- Is fully color-managed, works with ICC profiles
- Provides batch-processing of images (printing, scaling, format conversion, …)
- Allows placing several images on one output page
- Automatic image scaling for optimal prints. Offers several different scaling algorithms.
- Offers sharpening (optionally).
- Offers selective color correction and fine-tuning
- Has an image-oriented browser for selecting files for printing

The user interface seems somewhat dated requiring a bit of learning, partly due to the large number of settings involved. This, however, provides a lot flexibility.

There are a number of features in Qimage which we do not use – e. g. image editing, RAW conversion, Flash Card import or import via TWAIN (scanner).

You may download Qimage from the internet and test it (fully functional) for 30 days. If you buy a license (on the internet), a license-key is sent by e-mail. Installation is trivial – click on the installation file. There is not much to setup; you should, however, check if the monitor profile is correctly selected (Qimage accesses the Windows system default profile).

Qimage actually is not a true RIP. Instead of doing its own dithering and color translation, it uses the manufacturer's printer driver for

actual output to the printer. While this implies limitations, it also offers the advantage of a great many printers being supported.

It performs several important printing tasks:

- It does up- or down-sizing of the image to an optimal printer's native resolution. It offers several different sizing algorithms, and is quite good at it.
- It does some sharpening (may be activated or deactivated).
- It offers some helpful administration tasks – **e.g. saving and** loading printer driver settings.
- Placing several images on one output page, which may be useful for simple production of contact sheets.

After starting Qimage, browse to your image folder. Qimage will build up thumbnails and display all images in the folder in thumbnail view (see figure 6.1). This may take a few minutes when entering a folder with many images. Once in the proper folder, you may hide the Folder Browser (toggled by F4).

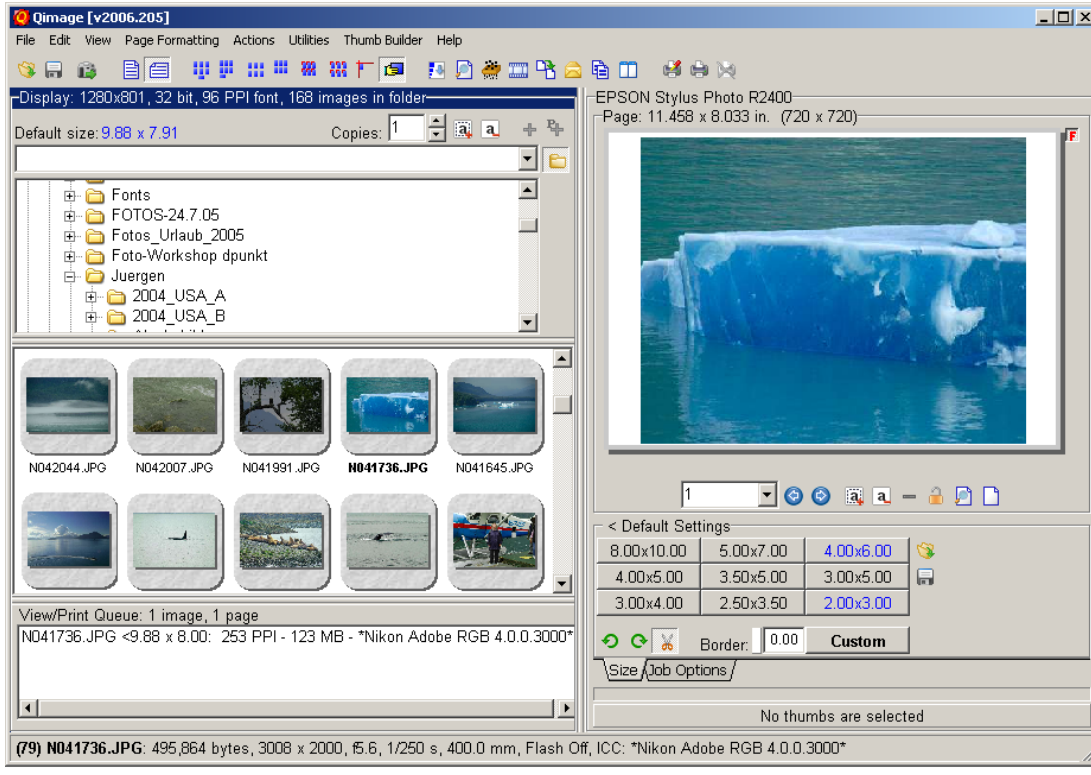

Figure 6-1: Qimage Pro window with folder browser open

Before actually beginning printing (building print jobs), setup these three settings:

- Printer setup (click or File ▸ Printer/page Setup)
- Page setup (page size, orientation, borders, …), (Page Formatting)
- Setup for interpolation and sharpening (Edit ▸ Preferences ▸ Interpolation)

Printer setup This brings up the standard print dialog of your printer (printer driver of the operating system), where you may select all settings. These settings are stored by Qimage and may be saved under a special name.

Interpolation and sharpening Select your interpolation method for up- and down-sizing. Qimage offers various different methods and indicates their respective quality and speed (Qimage Lite shows a simplified dialog).

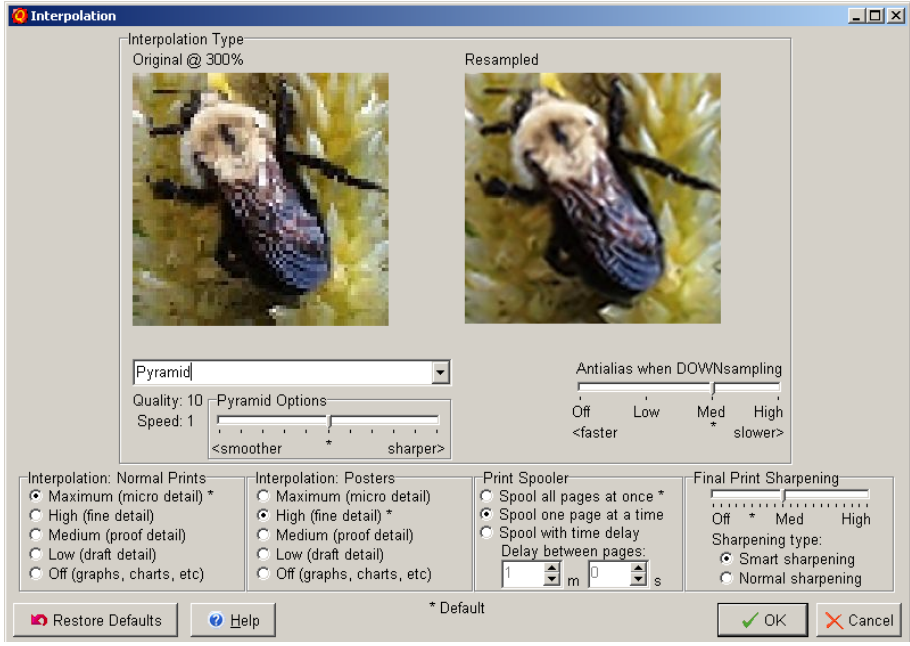

Figure 6-2: Setup your interpolation and sharpening parameters (Qimage Pro)

Additionally, check the color management setup. By default, Qimage uses the monitor profile set by the operating system. Here define the rendering intent used for printing (see Chapter 3.2, page 3-14).

To print an image, merely drag your image icon onto the empty page icon (figure 6-1). You may still modify placement on

the page. Alternatively, you may select the image thumbnail and just click . (calls up a Preview of the image).

When selecting several images and clicking , they are placed automatically on the page using the current image size selected in the page window portion – as many as possible to a page while automatically creating additional pages (print jobs) as needed. You may delete individual images from a page or modify placement.

Images printed with Qimage show a somewhat more crisp appearance compared to printing from Photoshop. This should be attributed to the optimal scaling done before passing the composed page on to the printer driver, as well as, to sharpening done by Qimage (you may deactivate sharpening). If you must up-size significantly, the up-sizing algorithms of QI definitely help achieve a good result, and you usually get by without a third-party up-sizing package, even when up-sizing significantly.

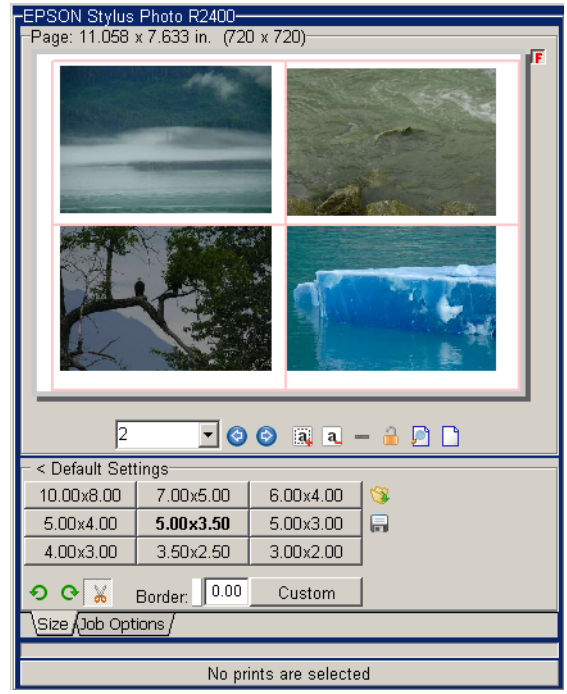

Figure 6-3: Image placement on your page

Digital Domain ([31]), the maker of Qimage, offers a number of printer profiles for selected Epson and Canon printers. We have not used them, as we prefer proven manufacturer profiles (as listed in Chapter 5) or our own custom profiles.

Digital Domain also offers a simple printer profiling package (Profile Prism) that uses your flatbed scanner for reading the printed color patches (it first profiles your scanner using a special target). It is not as accurate as with a professional printer profiling package, but should be much better than no adequate printer profile at all.

6.3 Printing using a RIP

As mentioned, there are a number of good RIPs for fine art printing on the market. We begin with a good, reasonably-priced RIP, and later, move on to RIPs focused on press work (CMYK) proofing.

Quad Tone RIP

Some personal history: We've known Roy Harrington for some years, meeting as members of the *Gallery House*. Roy is a passionate 4×5 B&W landscape photographer who has produced inkjet B&W prints for some time now. In Spring 2003, Roy bought our Epson 7500 (we were upgrading to the 7600). He began experimenting with different B&W quad tone ink sets. Here, he was not alone. But, because Roy also knows programming inside and out, he began to write his own quad tone driver for his inks and the 7500. From this project, evolved the new tool called *Quad Tone RIP*. When Roy told us that he gets as good results from standard Epson Ultrachrome inks (Epson 2200/7600/9600) as from his own ink mix, we became curious, as we believe Roy understands digital B&W printing at an extremely high expert level.

Quad Tone RIP [58] (QTR for short) is now available for Mac OS X, as well as, Windows. On the Mac, QTR works like a printer driver. On Windows, it's actually a set of batch programs outputting through the standard Windows printer driver. Handling on Windows originally was not as smooth as with Mac OS X, but with version 2.3, it got a new front-end graphic user interface making handling (printing) with QTR easy and convenient. QTR is a shareware program and for 50 $ US it is little money for what it offers. You may download it from the internet and try before you buy.

QTR focusses on B&W printing. It does not offer PostScript support, but only TIFF (uncompressed or LZW) – making it small and simple. You may also output color images, however, they are automatically converted to B&W.

QTR supports a number of Epson printers (desktop as well as large-format) with several different ink-sets (e. g. UltraChrome, UltraChrome K3, Neutral K7, QuadBlack and Ultratone). The package includes additional tools for ICC B&W profiling, not easy using standard ICC tools (you will need a spectrophotometer for that).

Installation

As QTR comes with an installation script, installation is quick and easy. On Mac OS X, you have to be sure that *GIMP print* is installed before installing QTR. (If it is not, you may simply install it from your Mac OS installation disk, using *Optional Installs.mpkg*. When you reach Custom Install, select Printer Drivers, and check *Gimp Printer Drivers*).

The QTR install script will install the RIP. Next, you must install the ICC profiles for your printer. These profiles come along with the package.

The driver will **not** show up immediately in your printer list. First you must add a new printer using your Mac *Printer Setup Utility* (). There, select the printer (already installed and online) you want to use for your B&W printing using QTR, and use *QuadTone RIP* from the Print Using list. Additionally, select your printer model from the drop-down list (see figure 6-4).

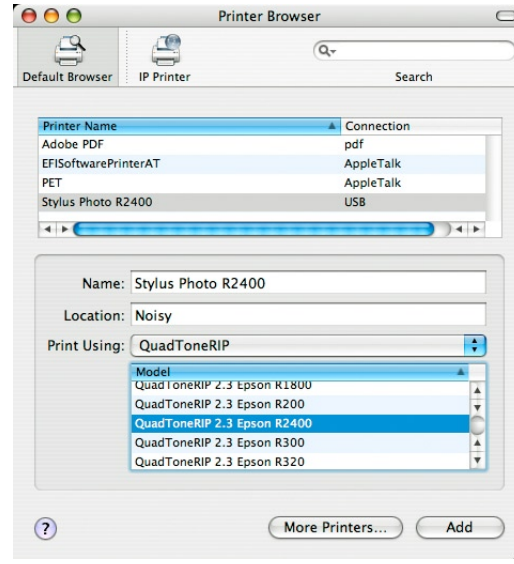

Figure 6-4: Select 'QuadToneRIP" from the 'Print Using' list and choose your printer model

That does it. From now on, you may use QTR like a regular printer when printing from an application such as Photoshop.

Printing with QTR under Mac OS X

We use Photoshop as our printing application – selecting Print with Preview – and leave color management to the printer (see Chapter 5.3, page 5-6).

In the setup of the printer driver, first select Printer features and then select your media type and Dither Algorithm (which we leave at *Ordered*). For our Epson R2400, QTR not only offers Epson papers, but several others (e. g. Ilford Heavy, Transparencies and Glossy Film).

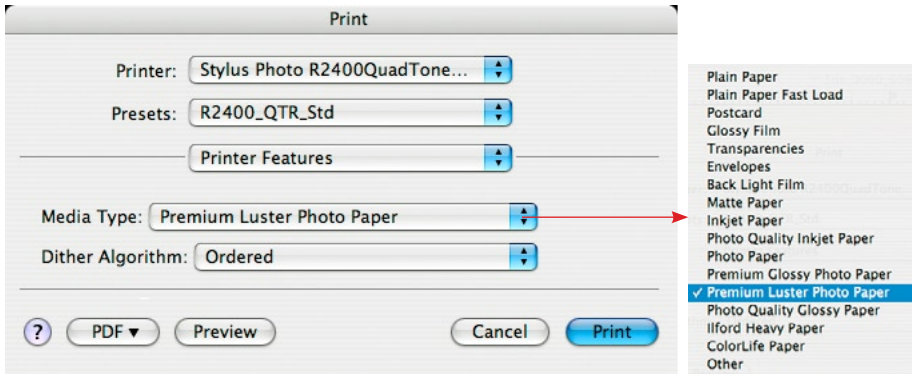

Figure 6-5: First select your media type.

Now (still in driver settings), go to tab QuadTone RIP (see figure 6-6). Here, you do your setup for B&W prints:

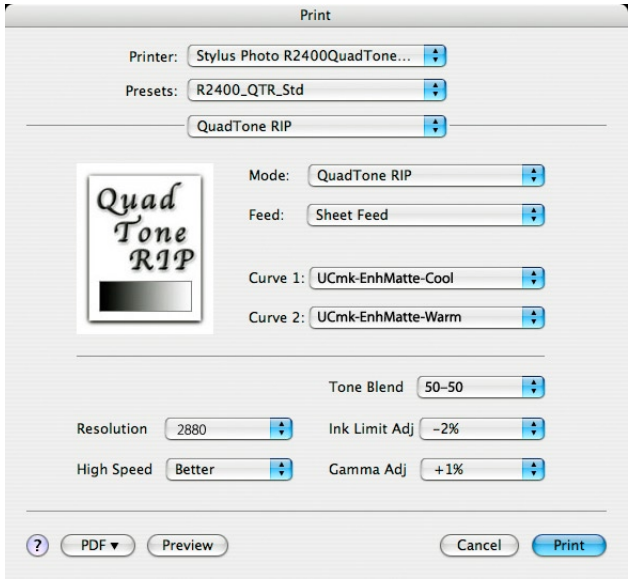

Figure 6-6: Under the tab 'QuadTone RIP', you do your actual setup for the B&W print.

Curve 1 and 2 boxes determine your ink+paper profile (including your color hue). There are curves for a cool, as well as, curves for a warmer color. You may mix this color hue via the *Tone Blend* drop-down list. A 50-50 blend, as in figure 6-6, will result in a neutral tone. *Ink Limit Adj* and *Gamma Adj* give still more control of the print. A higher or lower *Gamma* value will darken or lighten an image in the print without requiring editing of your original image.

Printing with QTR under Windows

With Windows, QTR doesn't run as a driver. Since QTR 2.3, however, there is a convenient front-end application called *QuadToneRIP Graphical Interface* (QTRgui). It will be installed in your Windows Quick Start list. If you want to generate your own curves (e. g. for new inks or papers), you would install the *Curve Creator*, as well.

QTR offers a *Monitor folder* (a Hot folder). When you drop an image into this folder, is will be printed by QTR.

To print an image the simplest way, call up QTR GI and do your initial setup. Then, select the image you want to print (Image ▸ Select Image) and set the scaling (if necessary). QTR can only print TIFFs (Grayscale or RGB, uncompressed or LZW. 16-bit TIFFs will be internally converted to 8-bit), which, in most cases, is no real restriction in fine art printing. It takes most version of TIFFs Photoshop can produce.

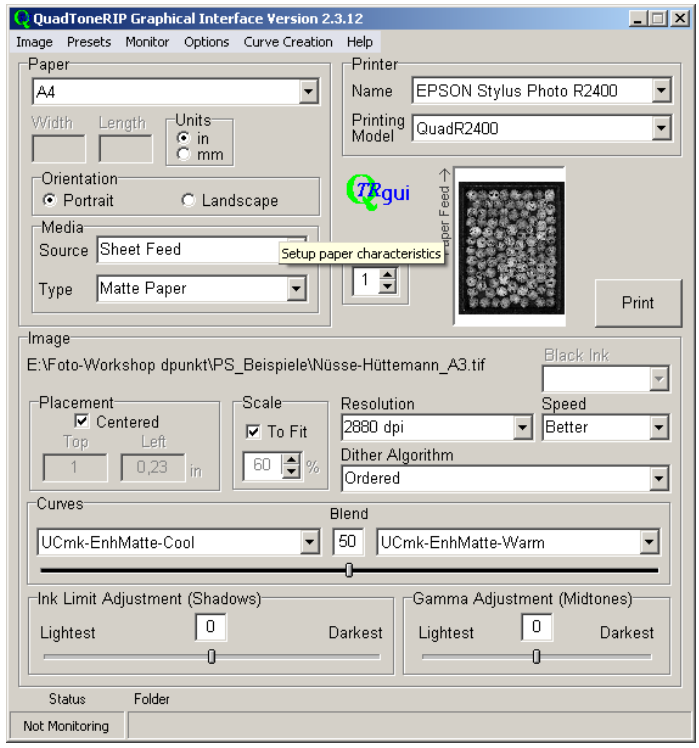

Figure 6-7: QTR Graphic Interface for Windows

One real strength of QTR lies in its capability for B&W profiling and linearization (a weakness is in its manual). For more details on profiling linearization and curves adaption, see the various QTR tutorials and help files.

ImagePrint by Colorbyte Software

ImagePrint by ColorByte ([57] ,) is a very popular RIP for fine art photographers. These are the main benefits of ImagePrint:

- Excellent print quality (does not use any part of the manufacturer's drivers).
- 16-bit-capable
- Very good profiles for many papers are included, as well as, profiles for different view lighting conditions. This is an important point, as creating good profiles can be quite time consuming.
- Very good B&W printing with very low levels of metamerism
- Easy to use when compared to other RIPs

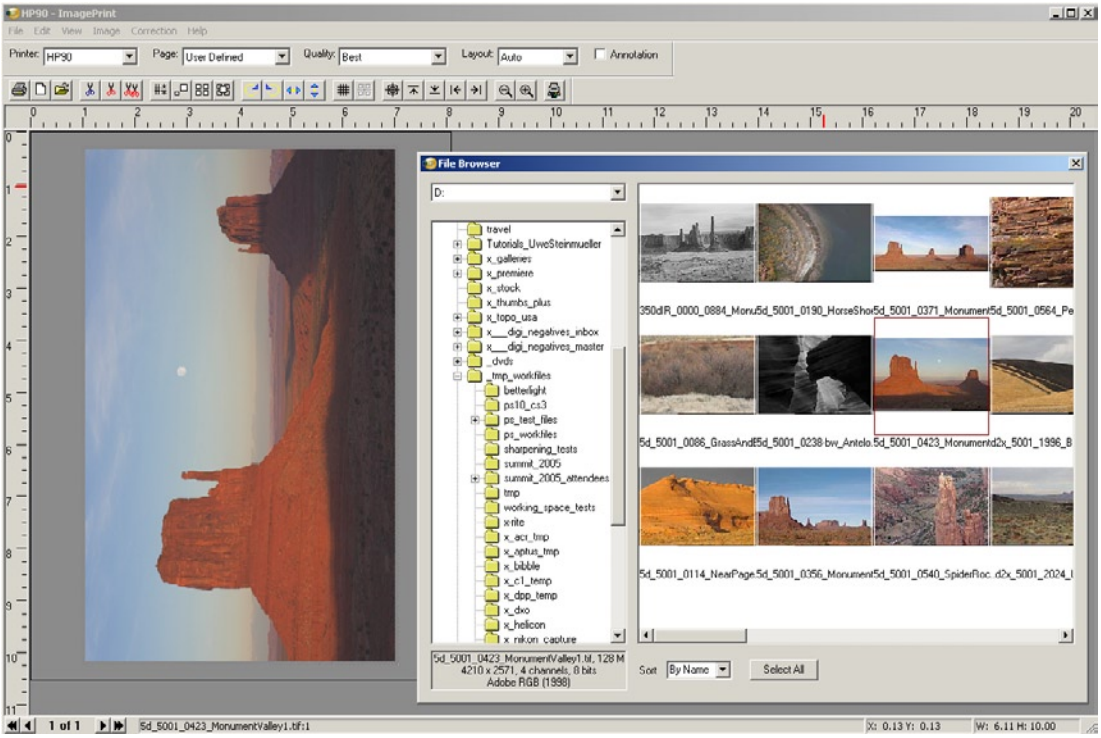

Figure 6-8: ImagePrint user interface

We have used ImagePrint for the Epson 7600/2200 and also for the HP Designjet 90, and have been very pleased with the result. Like most RIPs, ImagePrint lets you select one or more images (for fine art you usually will only print one image at a time), position it on the paper template, resize and finally print.

Color Management

Of course, ImagePrint is fully color-managed, but also provides extra control over printing. We cover the basics, as far as we use them ourselves. You may also do image corrections in ImagePrint, but we prefer performing these operations in Photoshop.

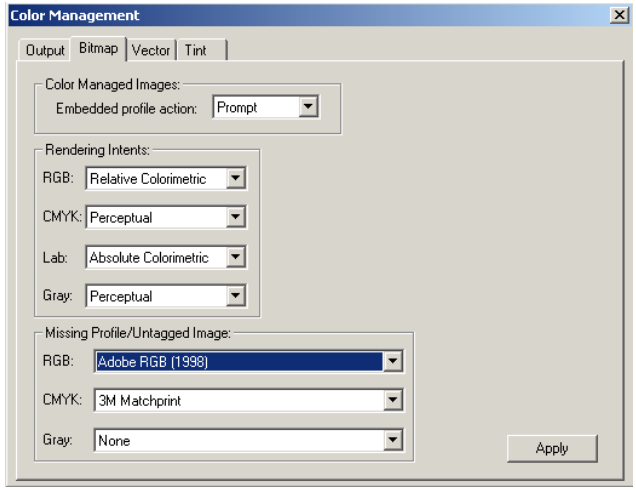

Figure 6-9: Color Management strategy

We want ImagePrint to notify us about the embedded profile, and use mainly *Relative Colorimetric* rendering intent for color images. For grayscale images, we use the *Perceptual* rendering intent.

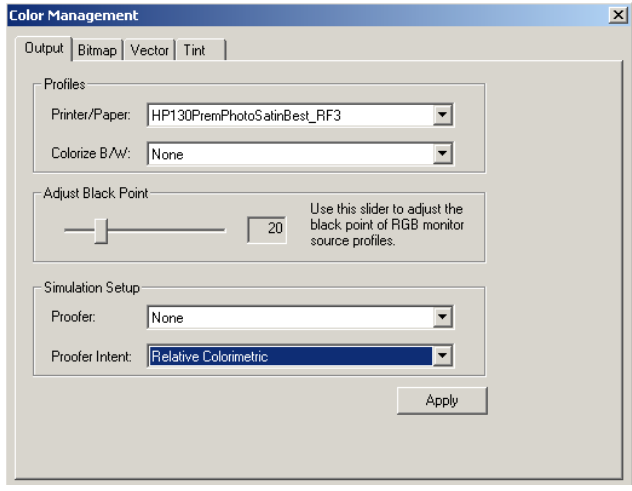

Figure 6-10: Output Options

The key property is the profile for the paper. ImagePrint has two different kind of profiles:

- Color Profiles for different papers and viewing light conditions (often 5 variations). The user can also create new profiles himself.

- Gray profiles for B&W printing on various papers. These profiles can only be created by Colorbyte.

In special cases, you can have a B&W profile plus a color profile to use the colorizing feature (We have no experience with this).

The Adjust Black Point slider is important, as you can define the level of black definition you want for your prints. We did tests, and left it at the level we liked best.

The simulation tab is set to "none" because we are not simulating any other target printers.

For B&W prints, ImagePrint features a powerful tint control:

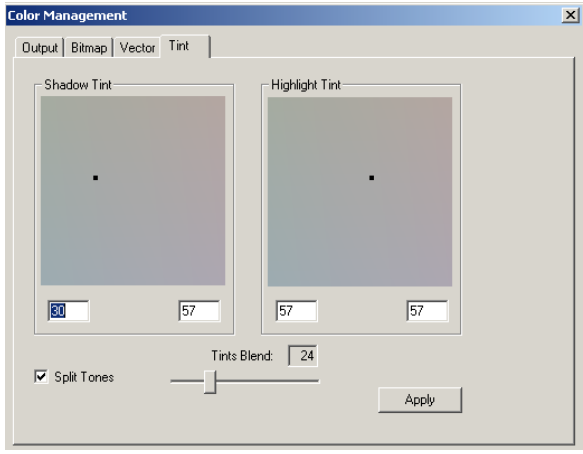

Figure 6-11: You may select different tints for Shadows and Highlights

We use the same tint for the entire image, but ImagePrint allows so-called *split toning,* where the shadow part of an image receives a different tone than the highlight part. You can also control, using an extra slider, where the split should be for your particular print.

For the HP Designjet 30/90/130 printers, ImagePrint also supports in-printer color calibration (these printers have their own density sensors):

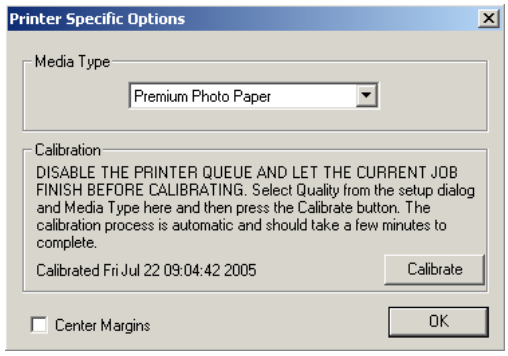
Printer Specific Options
Media Type
Premium Photo Paper
Calibration
DISABLE THE PRINTER QUEUE AND LET THE CURRENT JOB FINISH BEFORE CALIBRATING. Select Quality from the setup dialog and Media Type here and then press the Calibrate button. The calibration process is automatic and should take a few minutes to complete.
Calibrated Fri Jul 22 09:04:42 2005
Calibrate
Center Margins
OK

Figure 6-12: Calibrate dialog

EFI Designer Edition

EFI [67] is well known for its PostScript RIPS (Fiery print controllers) for color laser printers. *EFI Designer Edition* is a software RIP. Running under Windows (XP and W2K), as well as, Mac OS, it is suited not only for fine art printing, but also allows doing highly reliable proofs of images for press printing. It provides an *Ugra/Fogra Media Strip* (a color controlling tool well established in Europe's press industry). It includes several profiles for this kind of proofing and for a multitude of different papers for supported printers from Epson, HP, Canon, Encad and Roland (and others) – mainly professional inkjet printer types. It offers Adobe PostScript 3 compatibility, as well as, PDF and tagged TIFF (RGB as well as CMYK and Lab).

It may be installed as a virtual printer driver and thus used by any application on your system. It also support 'hot folders' – when you drop an image (PostScript or PDF file) onto its hot folder, the image is added to the print queue and processed according to the rules defined for that folder. Thus, the virtual printer may also be used in a network if the folder can be shared. It is fully color-managed and provides extended profile options. You may add linearization files to profiles. Additional tools help build linearization files and build connection profiles (these are profiles that combine profiles allowing simulation of the printing behavior of device B on device A).

With a price tag of about 650 $ US, EFI Designer edition definitely is not a throwaway application.

EFI Designer Edition (EFI-DE for short) offers three different printing modes:

- **Proof** (simulating a press print on your inkjet printer)
- **Photo print** (very much like printing from Photoshop, but with the additional advantage of batch/spool processing)
- **Black and white print** (converting an image to B&W on the fly)

You may also export a job (rendered as TIFF).

As EFI-DE comes with a good installation script, installation was complete in a few minutes. I had to update this version online (just another click) to get support for my Epson R2400.

To setup the RIP, select Preferences and set the parameter for:

- **Printer** settings
- **Paper profiles** settings
- **Color** (including color output mode – *Photo* for fine art printing)
- **Output**. Here, you define the RIP's resolution and what kind of additional control information should be included for the print.

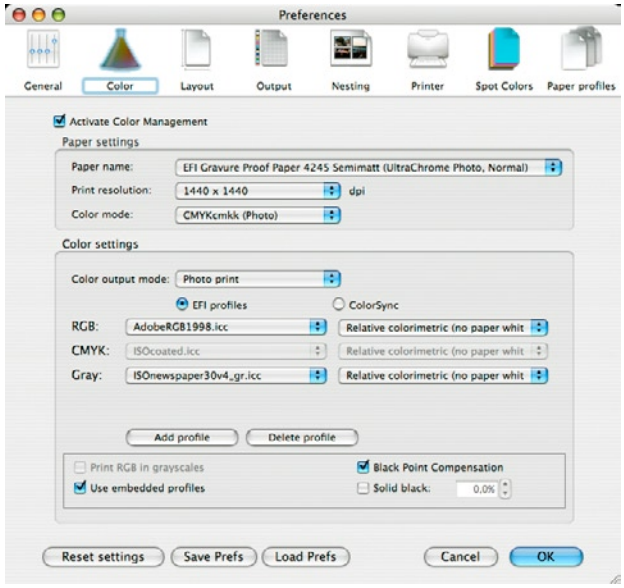

Figure 6-13: Color setup for your printer

Additionally, using the tab General, setup where your hot folder will be and where exported and preview images should go.

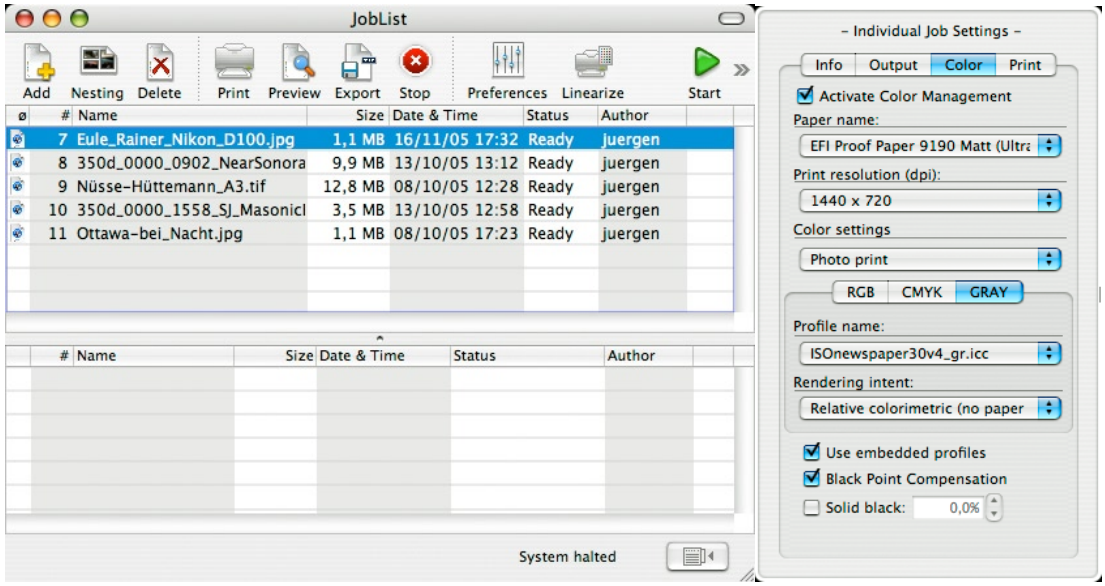

Figure 6-14: Job list of EFI Designer Edition.

For fine art printing, we prefer using drag & drop, dragging the image file onto the open job list. Selecting a job and clicking will show the details (right palette of figure 6-14). Here, you may still change some of the job parameters (as long as printing has not started).

EFI-DE does a acceptable job in fine art printing – you may even improve profiles by building a linearization file for a printer and paper using the *Ink Assistant* . (Here, you adapt gamma, as well as, individual ink curves – however, only for CMYK inks.) You may also build custom ICC profiles. EFI-DE offers a pass-through option for the print of the target and allows importing the new profile (you still need a separate profiling package). However, apart from color management (which is important), there is no special support for fine art printing, though for test prints the nesting feature comes in handy.

Its real strength lies when doing a proof before sending your files to a printer for press printing. If your image is part of a DTP document, PostScript and PDF support turn out to be important. The Ugra/Fogra media-wedge is another plus for this kind of jobs (if bought separately, it makes up about half the price of the EFI-DE package).

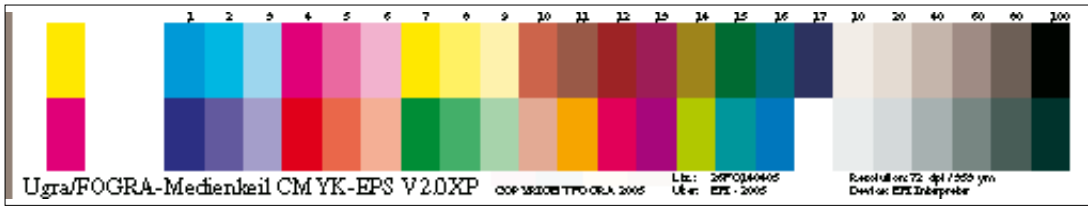

Figure 6-15: Ugra/Fogra Media-Wedge may be used as a control strip for printed colors

In Europe, this may be used to verify the color/print quality of a press print. You may also proof using spot colors, and there is a *Color Editor* to define additional spot colors. For press proofs, the virtual printer driver is convenient, as you may print from any DTP application to a (supported) non-PostScript inkjet printer.

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Chapter 7

Black & White Prints

Camera: Canon 350D (infrared modification)

At first glance, printing B&W seems easier than color. Unfortunately, this is not the case. The main reasons for this are:

- Finest tonal gradations in B&W prints are more important
- Unwanted color casts
- Toning of the prints
- Metamerism (one of the major problems B&W inkjet prints can face)
- Excellent black levels are difficult to achieve

The key issue with most inkjet printers is that they only feature one black. Using only one black leaves two options:

- This will get you very grainy looking B&W prints and hardly any good highlights
- Using all colors to print B&W: Potentially introduces various color casts and also can create strong metamerism (prints look greenish outdoors and/or can have a magenta cast under tungsten light.

The previous generation of UltraChrome™ Epson printers (2200, 4000, 7600, 9600) featured at least two blacks. With these printers you could get good B&W prints using the ImagePrint RIP. Using just the Epson drivers would still result in prints showing quite a bit of metamerism and bronzing.

There were some third party inksets on the market that could transform your inkjet printer into a pure B&W machine. Well known are the Piezography inks by Jon Cone. But there have been some issues with ink clogging in the past.

In 2004 we saw the first off the shelf printers from HP (e.g. HP Photosmart 8450) that featured color printing with an additional (or optional) three shades of black inks. Then, in 2005 HP launched the Photosmart 8750 (improved and larger version of the 8450) and from Epson the new UltraChrome™ K3 inksets (where K3 stands for the three blacks). Now, for the first time, we can create quite amazing B&W and color prints on the same inkjet printers. Only the Epson printers cover the range from 17" up to 44" printers right now while HP is limited to 13" for printers with three blacks.

Note: In fact, the lighter blacks are very important in these printers, as it produces smoother results in building up darker tones adding more lighter blacks than lighter tones with sparse darker blacks.

Here are some options for good B&W printing:

- HP Photosmart 8450 or 8750
- Epson R2400, 4800, 7800, 9800
- Epson 2200, 4000, 7600, 9600 with ImagePrint or Quadtone RIP
- Custom third party inksets or even home made diluted inks with third party RIPs (like StudioPrint or Quadtone RIP). We know pho-

tographers that use up to 7 inks). Many use the classic Epson 2000, 7500 or 9500 printers.

We do not plan to cover the use of custom and third party inks in this book. Here, you are better off checking out specialized forums on the net. We stay with solutions that work off the shelf and additionally allow you to print color and B&W using the same printer.

7.1 Workflow for B&W prints

The workflow for B&W prints is not much different than that for color. Some leave the image in RGB color mode, while others convert files into grayscale images.

Tonality is everything in a good B&W print. Some may prefer a stark contrast, while others search for ultra-smooth gradations and open shadows.

One of the major issues in B&W printing is good, soft proofing. Until recently, it was quite a hassle to find a decent solution. Fortunately Roy Harrington (creator of QuadTone RIP [58]) offers a solution (see chapter 6.3 and section 7.5).

From color to Black & White

There are nearly as many ways to convert a color image to B&W as there are ways leading to Rome. Some newer digital cameras even shoot in B&W – though we do not recommend it, as a computer-based conversion will give you more control. You may also convert your color image to B&W either in your RAW converter, as described in our e-books (see [20] and [22]) or in Photoshop.

When you do it in Photoshop, simply converting from RGB to Grayscale (Image ▸ Mode ▸ Grayscale) in most cases does not achieve optimal result.

A better way is using the Channel Mixer of Photoshop:

1. Activate your Channels Palette and determine, which of the RGB channels carries the most information (don't look at the channel icons, but at your image and deactivate the RGB channel first). In our example of figure 7-1, it is Red and Green – which often is the case.

Figure 7-1: Original color image

Figure 7-2: Look for the channels with the most information

2. Create a new Channel Mixer Adjustment Layer (Layer ▸ New Adjustment Layer ▸ Channel Mixer).

3. Enable option Monochrome and start pushing the slider of your most important color (channel) slowly to the right. You may now mix your three channels. The sum of all three should add up to 100 %. Basic values of Red = 60 %, Green = 40 % and Blue = 0 % will give you a good start. In many cases, this already will be it (We extracted these values from Clayton Jones paper on B&W conversion).

   This involves a bit of trial and error. You may even set a channel slider to a negative value. Carefully check your image while adjusting the sliders.

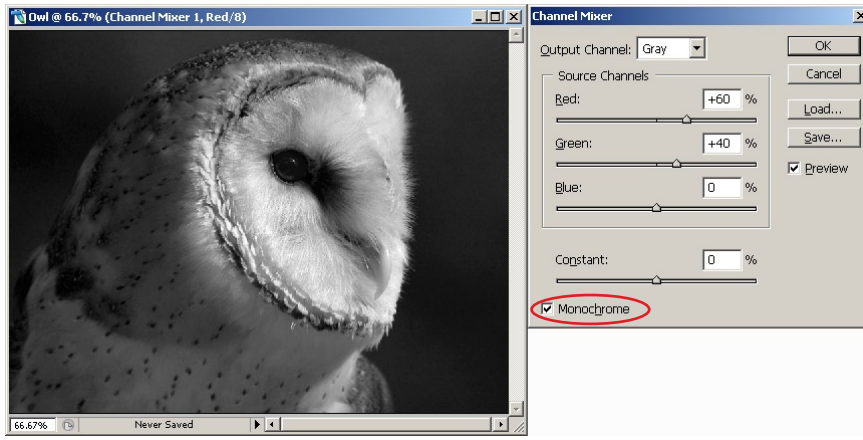


Figure 7-3: Tune you channel sliders, until the image looks OK.

4. If the image looks good, click OK. Though the image now looks B&W, it is still in RGB – which has some advantages for further optimizations.

5. You may still apply additional fine-tuning – e. g. using Levels and Curves. We recommend using adjustment layers for this! Fine-tuning a B&W image is a bit different than color, but the same tools may be used.

As mentioned, there are a number of additional ways for color to B&W conversions, and you will find quite a few Photoshop plug-ins for this task. For exmaple we like to use *B&W Studio* by PowerRetouche [63] or ConvertToBW Pro [65] and recommend both – but these are just two of the many converters or plug-ins available for this purpose.

7.2 Printers with B&W-enabled drivers

As mentioned, some new printers feature three black inks and produce very good B&W prints.

B&W with Epson UltraChrome K3 printers

We show the principles with the Epson R2400 driver dialogs. We understand the other printers are virtually the same.

Again, we use Photoshop as a printing application. We open the image and call up File ▸ Print with preview. While when producing color prints we use the Photoshop Color Handling setting *Let Photoshop Determine Colors* (see chapter 5.3, page 5-6), when doing B&W prints, we *Let Printer Determine Colors* – meaning do the color management:

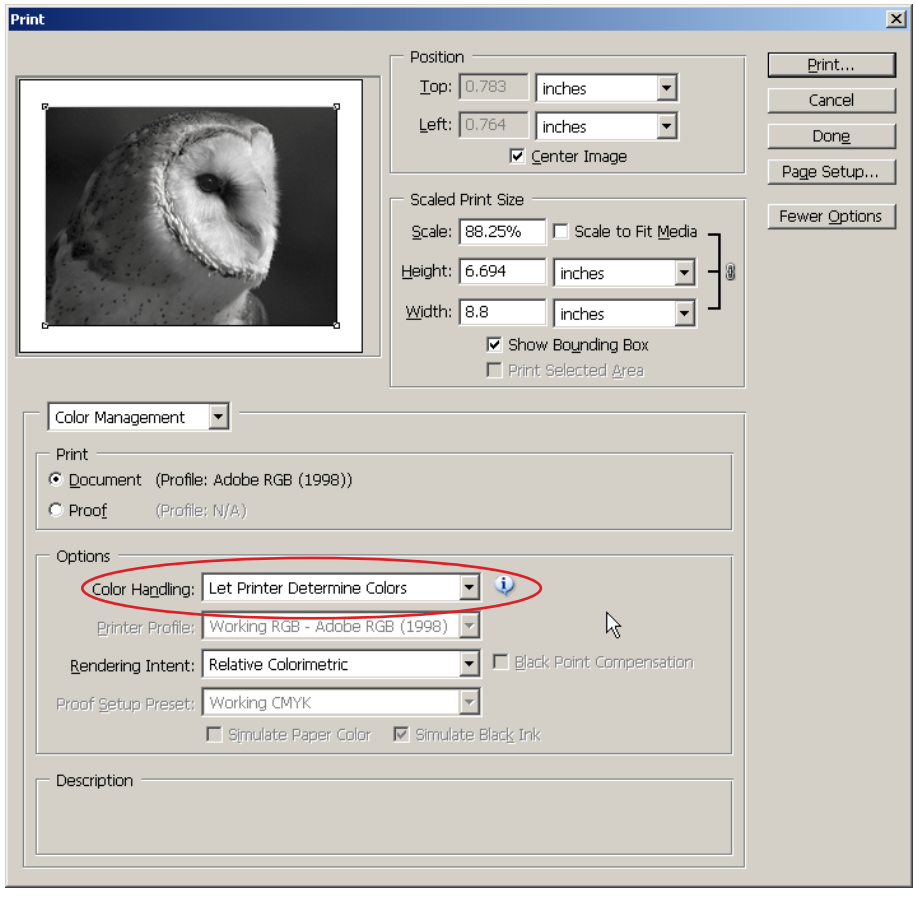


Figure 7-4: With B&W-enabled drivers, let the printer driver do the color management

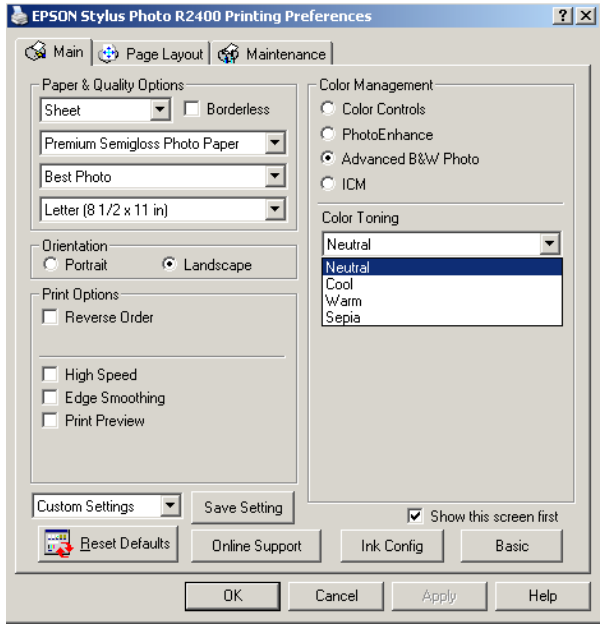


Figure 7-5: R2400: printing in B&W

Set the driver to Advanced B&W Photo. There are four standard options available: neutral, cool, warm and sepia. Best to start with neutral. We liked the results very much. If you want to fine-tune toning and settings, select the Advanced B&W Photo dialog.

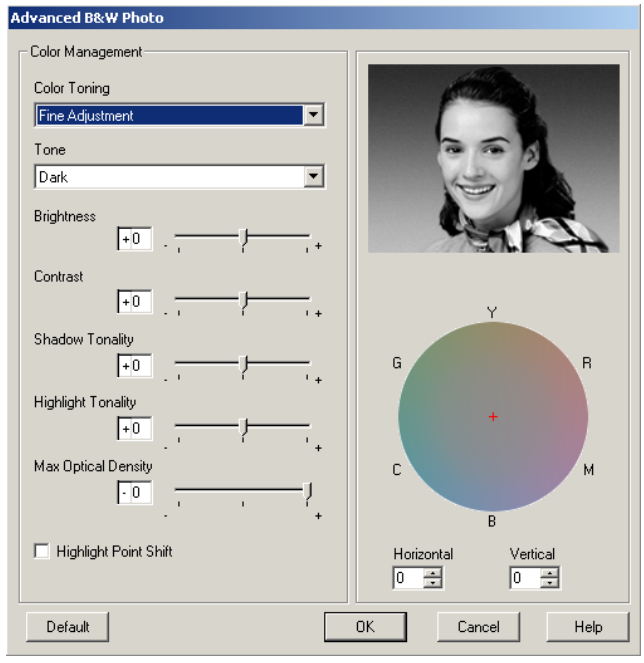


Figure 7-6: R2400 Advanced B&W Photo dialog

Aside from the actual toning, you may first want to set a tone (maybe "shadow brightness" perhaps another term) you like:

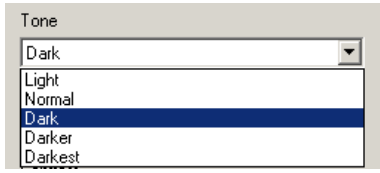


Figure 7-7:
Tone settings

We found the default setting of Darker too dark and changed the setting to Dark.

Be very careful using too strong toning as you may get into a zone where prints may show some metamerism.

If you use the Advanced B&W Photo for the K3 printers you should not handle color management in Photoshop but leave it to the printer. You have to gain your own experience on how the image on the screen is related to the print in terms of tonality as this workflow is not really color managed. We assume that the driver treats photos as a grayscale image and then performs its toning. Later in this chapter we have a note on soft-proofing B&W prints.

B&W with HP Photosmart 8750/8450

HP shipped the first consumer/prosumer inkjet printers with three black inks.

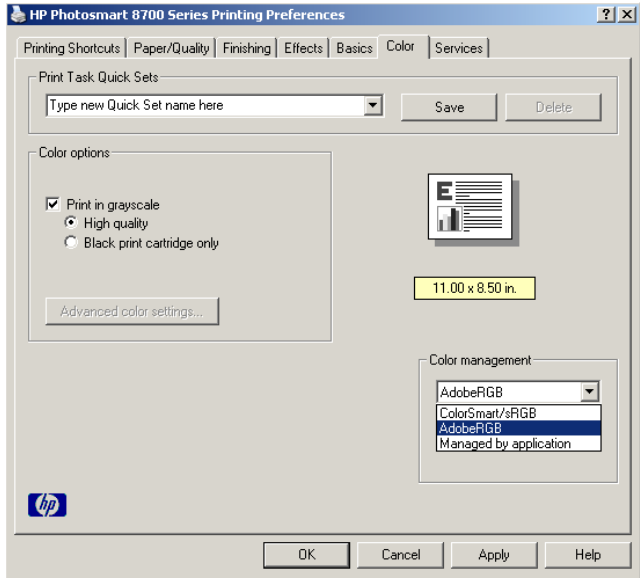


Figure 7-8:
Setting the 8750 for B&W printing

- Select Print in Grayscale and also High Quality.
- Set Color Management to sRGB or Adobe RGB.

Using the 8750 for B&W, you should not handle color management in Photoshop, but leave it to the printer. You have to gain your own experience how the print shown on the screen is related to the print in terms of tonality as this workflow is not really color managed either.

7.3 Special software (RIPs) for B&W

If your printer has but one black ink, it is quite difficult to achieve a neutral image without a color cast. In this case, a RIP, specialized for B&W printing may help. The same is true if you print using multi-black third-party inks (e. g. quadtone inks).

Colorbyte's ImagePrint

ImagePrint earned Colorbyte [57] the reputation of producing very high quality B&W prints from an Epson UltraChrome™ printer generation (2200, 4000, 7600, 9600) with only two blacks. It also uses special techniques to prevent major metamerism for B&W prints.

We recommend using ImagePrint for B&W only on printers that use at least two blacks. The B&W prints for the HP Designjet look very good but also show strong metamerism when you view the images outside in daylight (although you can compensate for this by using the right tint).

We have covered ImagePrint before (see chapter 6.2, page 6-12). This is why here we concentrate on the features needed for B&W printing.

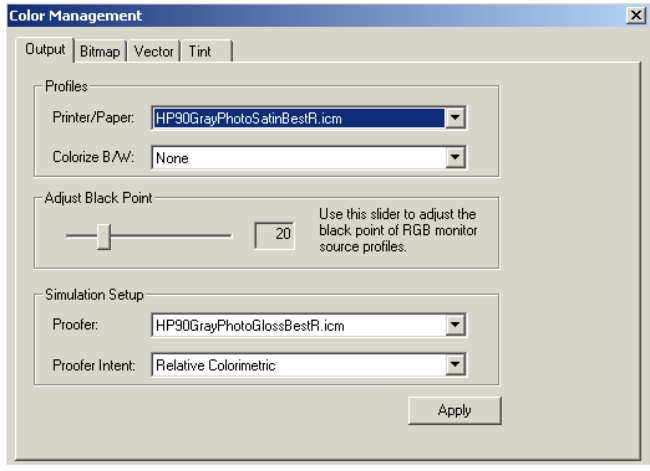


Figure 7-9: ImagePrint 6 B&W color management settings

By selecting an ImagePrint 6 grayscale profile, ImagePrint is set for B&W printing. These grayscale profiles can only be created by ColorByte. Fortunately, ColorByte covers many different papers.

You should also find which black point you prefer for your B&W prints.

Photographers actually have very different preferences as to how a B&W print should look (even varying from image to image). Some like them cool, others warmer. This factor creates a need for print toning (also to compensate for the original black tones of the printers).

ImagePrint has very sophisticated controls for toning images:

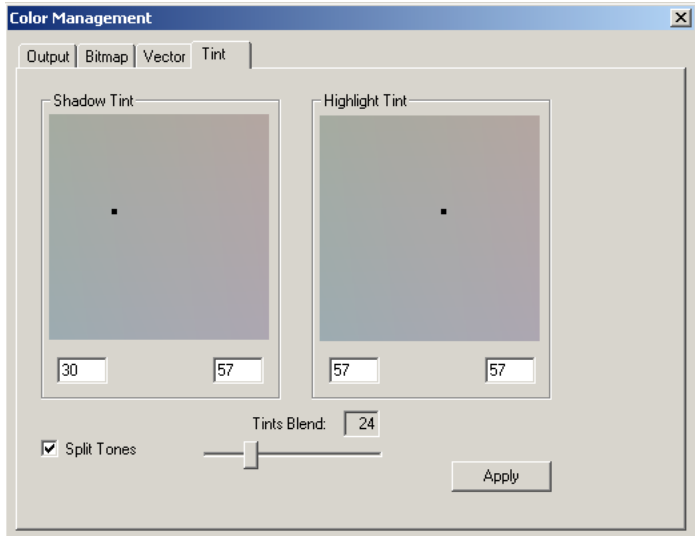


Figure 7-10: ImagePrint 6 tint control

The tint control allows more different tones than you ever want to use. It even allows tinting shadows differently than the rest of the image by so-called *split toning*. Best you experiment with your printer to find the ideal tint and stay with it for future prints.

If you work a lot in B&W you should check out ImagePrint for your workflow.

QuadToneRIP

The large format B&W photographer Roy Harrington looked for a simpler and less expensive alternative to ImagePrint that he also could adapt to customize B&W ink sets. So he created his own RIP: QuadTone RIP.

We have seen prints made by Roy with QuadTone RIP and they looked very good, indeed. We covered QTR in our RIP chapter 6.

We will not get into details here, but you may also want to check out this software (you can download QTR form [53] and try the software before you buy [58]). See chapter 6.3 'Printing using a RIP' for more details.

Other solutions

- Using StudioPrint RIP [30]
  (non-PostScript) supporting third-party ink-sets as well as quadtone inks. It provides a very good linearization process.
- Jon Cone's Piezography Neutral K7 ink-set [45]
  – an ink-set with several different black inks and profiles to support them.
- InkJetControl™ (see [65] and [46])
  is software dedicated on B&W printing and comes together with OpenPrintMaker™.

While we prefer to use either B&W-enabled printer drivers for printers that have several black inks or we use a RIP – such as QTR or ImagePrint (see chapter 6.3 'Printing using a RIP'), some photographers swear by 'Black Only' (BO) printing, using just a single black ink for their prints. The results they achieve for their kind of images is very good. The advantage of this technique is in its simplicity and low cost. Clayton Jones offers a nice feature-page at [64] on this aspect.

7.4 Papers for B&W prints

Finding the correct paper for B&W is even more complicated and demanding than good papers for color. Why? The classic B&W printers are based on silver-based photographic papers quality levels that are not that easy to match. As with color, there are three sorts of papers that photographers like:

- Matte fine art papers
- Satin papers with a very soft gloss finish
- High gloss papers

As we discussed, you cannot reach the same contrast and Dmax (maximum color density) on matte papers as is possible on glossy papers. On the other hand, some matte papers, with their soft cotton surfaces, look just great. Here, we only list papers we know and consider very good:

Matte Fine Art Papers

- **Hahnemuehle Photo Rag / (Satin)**: Very popular, expensive and you have to watch for scuffing and cotton dust.
- **Somerset Velvet Photo Enhanced**: Very nice paper. One of our favorites.
- **Moab Entrada Natural**: Excellent, reasonably priced paper.
- **Epson Ultra Smooth**: Top paper, that is also archival. Watch for cotton dust, however.
- **Crane Museo II**: Very fine paper.
- **Arches**: Paper with a very good reputation. We have not not had a chance to check it out, yet.

Satin or soft gloss papers

Most of these papers have a slightly plastic feel. More an issue in open portfolios than behind glass.

- **Epson Premium Semimatte**: Nice surface for a satin paper.
- **HP Premium Plus Satin**: Very nice satin surface.
- **Epson Premium Semigloss**: Comes close to the Epson Premium Semimatte paper, but maybe not quite as nice.

We expect new papers in this category to show up in the very near future, as the demand for fine art inkjet papers increases.

High Gloss papers

- **HP Premium Plus Gloss**: Very nice glossy paper surface.
- **Pictorico Photo Gallery Hi-Gloss White Film**: Very special paper, that has an ultra smooth surface and also a lot of contrast and depth. It is rated to be very archival.

Clayton Jones, in his article "The Great paper Chase" at t [62], is another good resource on papers for B&W printing.

7.5 Softproofing for B&W

What you need is to soft-proof your B&W prints, as this saves you a lot of print iterations (meaning paper, ink and time).

Roy Harrington came up with a solution as part of his QuadTone RIP package (QTR for short). The package comes with a target and a program to create B&W profiles. Additionally, you need the GretagMacbeth Eye One spectrophotometer and a version of Profile Maker's Measure tool (a demo will do).

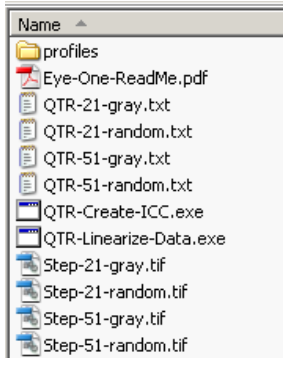


Figure 7-11: ImagePrint 6 tint control

First, you print the 21 gray target on your printer with exactly specified B&W settings (all B&W settings, paper type, toning, dpi, etc.) for your B&W capable printer (see beginning of this chapter). Let the print dry over night for optimal results.

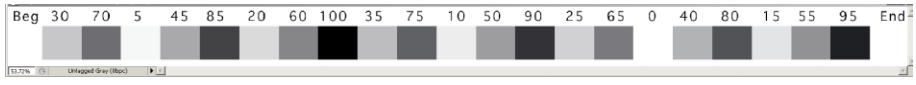


Figure 7-12: B&W target with 21 gray patches

Then launch the Profile Maker Measure tool and select the 'QTR-21-random.txt' reference chart:

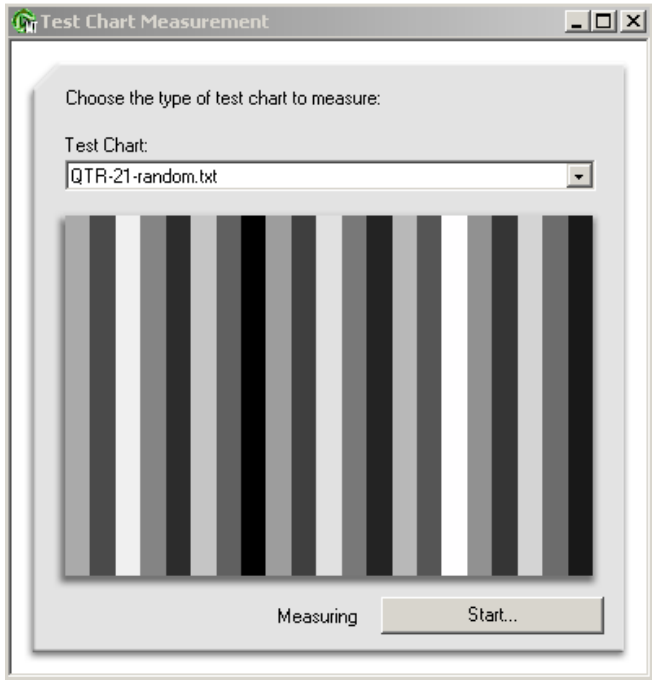


Figure 7-13: Select the chart

Start the measurement and read the line with the Eye One in strip mode:

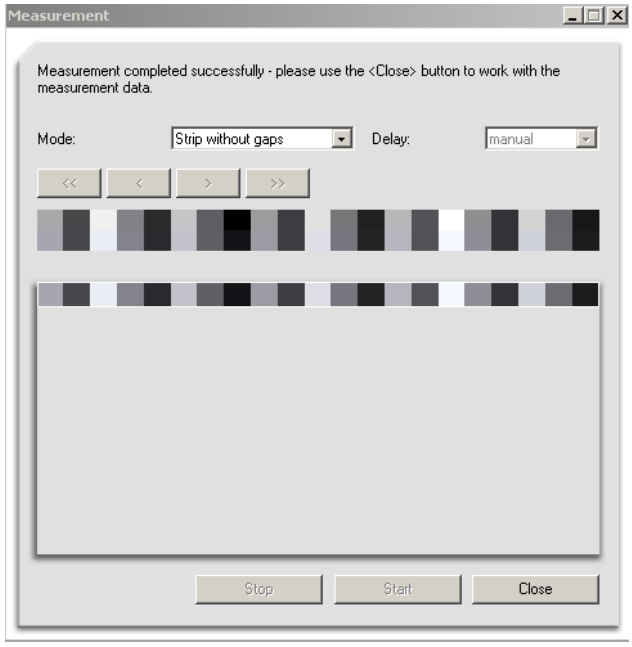


Figure 7-14: Read the strip

Finally, export the Lab values to a text file. Give it some descriptive name describing your driver settings (e.g. '*Eps_semigloss_neutral.txt*':

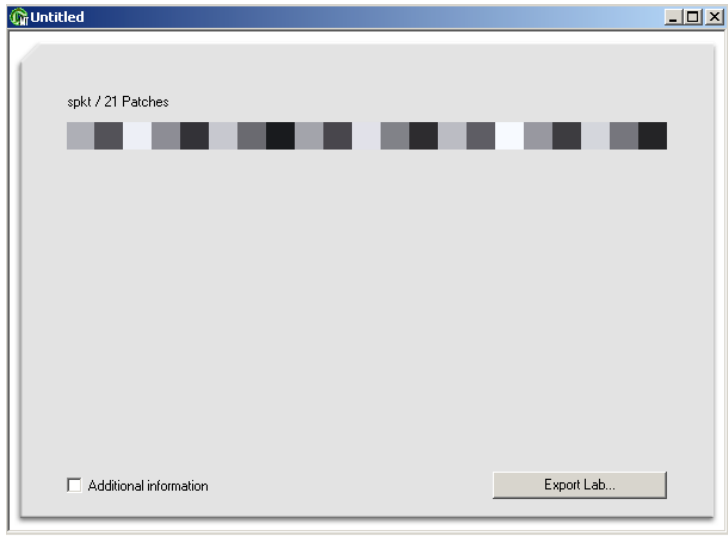


Figure 7-15

Now you just drop the text file onto the '*QTR-Create-ICC*' application and it will create a B&W ICC profile '*Eps_semigloss_neutral.icc*' for you: Install this profile into you system profile folder.

Now you can use this B&W profile for your softproofing in Photoshop: Here is how typical setup looks like (see also chapter 3.10 on softproofing):

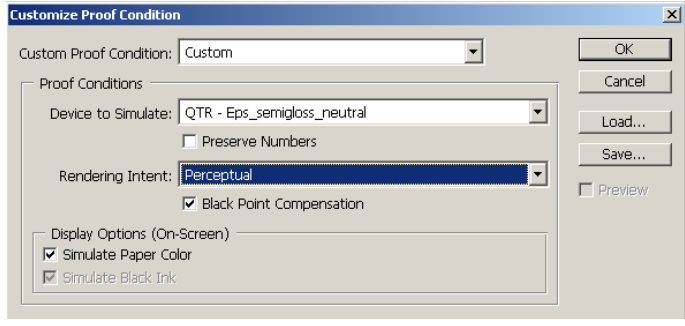


Figure 7-16 Setup you B&W profile for a soft-proof

Thanks to Roy Harrington, this problem now also has a simple and yet elegant solution. If you have licensed QTR, then feel free to share these profiles with other QTR users.

More information on B&W printing

Clayton Jones [64] has a very instructive Internet page on Fine Art Black & White printing. Uwe Steinmüller also provides a series of papers on B&W photography and printing (see [65]). He also provides a forum on 'Digital B&W processing and printing'.

Chapter 8

Image Judgement

Camera: Nikon D100

An image for fine art printing will be evaluated and judged probably many times, starting with the first inspection after downloading from the flash card of your digital camera or after scanning. Most probably, only very few of these photos will make it to fine art printing. Before you begin actually printing, you should give the image an additional very close inspection, looking for minor faults, like dust spots or dead or hot pixels. Do this at least at a zoom level of

100 %. Next, we recommend a test print be done on lesser quality paper and possibly a somewhat smaller sized print.

Repeat a close inspection, increasing scrutiny for minor deficiencies. It may even be helpful to use a magnifying glass. You may be surprised how many minor deficiencies you will find. Often, you can overlook minor defects – otherwise you'll have to go back and patch them in Photoshop.

A test print done on a paper different from the final print is useful for the purpose described above, but not for examination of the proper colors. This inspection is next.

8.1 Critical image judgement

Final inspection is for the correct colors of your print. As will be discussed in chapter 9.7 in some more detail, for a proper inspection of colors you should use daylight – standardized daylight D50. Why? Because that's the light today's color management systems target and rely upon. When you have a normal ICC profile, its colors are based on D50 light. Today, only a few profiling systems support other lighting (although this will be a feature any good packages will have in the future).

You might argue that the print will likely not be viewed under D50 light, since most *normal* lamps have a somewhat different light spectrum. Nevertheless, your first inspection for correct colors should be done using a D50-compliant lighting. How do you achieve that?

There are a number of ways – some simple and cheap and also more expensive ones:

- The professional way would be to use a D50 lightbox (viewing box) as seen in figure 8.1. There are boxes that serve for viewing and judging transparencies, as well as, prints (incident light). With some boxes you may even dim the light to a level at which you can compare the print to an onscreen image side by side, both with the same brightness level. This kind of box is the proper choice for print shops and final press work. With a price tag of about US $ 500–1,000 or more, they aren't cheap, and they take up valuable space on your desktop. Some of them offer different light sources, providing D50, D65 and D75.

Figure 8-1: Lightbox XL for viewing A3+ sized prints (Courtesy Quato Technology, Germany)

- Use of a D50-compliant luminary. This method is usually less expensive, about US $100–150. The point of these lamps is their D50-compliant light source and neutral white reflector.

*Figure 8-2: SoLux TrueColor **Task Lamp** with a light spectrum close to natural daylight (4 700 **K/D50**) (Courtesy **VP-Tailored** Lighting Inc.)*

There are several companies offering such daylight lamps – **e.g.** the **SoLux TrueColor Task Lamp** ([54], see figure 9-2), the **Ott-Lite** TrueColor light ([55]) or the Sol-Source by **GretagMacbeth** ([27]). The latter is the kind of solution we use.

When you wish to inspect large-scale prints, you will probably want to use color viewing lamps like GRAPHICLITE 100 by GTI Graphics technology ([75]) as they are used in printing compa-

nies. They consist of any array of fluorescent tubes delivering a color temperature of 5,000 Kelvin.

- Buy a D50-compliant bulb or tube and use it in a lamp having a neutral white or a pure silver reflector. Your investment will be a about US $ 15–25 (plus the lamp fixture). We recommend avoiding fluorescent tubes – at least in small-scale solutions – as their light spectrum is not even and typically shows several spikes (see figure 9-14 on page 9-13). SoLux, as well as Ott-Lite offer these kinds of bulbs/tubes. Some also recommend Philips TL-950 5,000 K fluorescent bulbs or Philips Colortone F40T12/C50 as reasonably priced alternatives.

Figure 8-3: Three types of 'daylight' bulbs. While the left two are more suited for image and color inspection, the right filtered, halogen-based bulb (SoLux MR 16, 4 700 K) may also be used for illuminating a print on the wall.

- Inspect your print in bright daylight. As the spectrum of daylight changes through the day, the best time for this will be around noon. Though the least expensive solution, it is also the least reliable one. If you must rely on daylight, you should at minimum use the light indicator strips described in section 8.2.

In most cases, your lighting does not really have to be exactly 5,000 K, but should be reasonably close to it. A light source in the color temperature range of 4,500 to 5,500 Kelvin is probably close enough, and an even color power spectrum is probably more important as color power spikes (e.g. most fluorescent tubes) may skew some colors. This is why we prefer daylight-balanced halogen lamps.

Before you begin a color inspection, the print should be completely dry. The time required for this depends on the type of ink and paper used, but 1-hour should be a minimum, as the color will slightly change during the drying process. If you intend to coat your print (see chapter 9-5), we recommend doing a second inspection after coating and drying of the coating. Coating will influence the appearance of colors.

For a critical color inspection, your environment should be color neutral. Avoid colored wall papers nearby or any other colored reflection from nearby objects. Use a neutral white, grey or black background for your image. Environmental colors influence your color perception! It is well worth first using a bright light – or working close to the lamp – for inspection and using a normal intensity light for color judgement. *Normal* here meaning about 150–400 lux, about the standard office light intensity.

Finally, there is a final kind of color inspection. This time, however, you should provide a light situation similar to one the print will probably be viewed under. This, again, may influence your colors plus some metamerism may occur (hopefully not). In some cases, you must go back in the entire printing process to slightly correct an image. Some newer versions of printer profiling packages allow for this eventuality when generating a printer profile (e. g. PULSE ColorElite ([29]) as well as GretagMacbeth Profile Maker 5.x ([27])). You want to have considerable experience for this kind of color and profile fine-tuning.

If you experience *bronzing* (Black being slightly copper-colored) or metamerism, utilizing a specialized RIP may help (see chapter 6.3).

8.2 Control tools

You may not have a D50 or D65 light box or other light source (e. g. a lamp) which complies to the lighting standard for image inspection. In this case, there are a few simple control tools available that may help judge lighting conditions. They are called *light indicators* and consist of some patches printed with colors showing strong metamerism. While this is undesirable in many conditions, here it helps: When patches show different colors (stripes), this indicates that your current lighting is off natural daylight (4,700–5,500 Kelvin).

If, instead, the different patches display the same color, your lighting is (probably) close to the lighting standard of 5,000 Kelvin:

Figure 8-4: GATF RHEM Light Indicator strip, showing under unsuitable lighting (left) and lighting, that is close to the view standard of 5,000 Kelvin (right)

You may order these patches from several sources (e.g. from the GAIN store [78]). Bruce Fraser includes such a patch-strip at the end of his excellent book on color management [2].

Still more accurate is a spectrophotometer, such as Eye-One Pro, the colorimeter Eye-One Display 2 by GretagMacbeth ([27]), PULSE ColorElite or the MonacoOPTIX by x.rite ([29]). Most of today's hardware-based monitor profiling tools come with a device allowing measurement of the color temperature of lighting. Some of the more expensive light meters also provide this.

Chapter 9

Presenting Fine Art Prints

Camera: Nikon D2X

When you have printed an image and you are satisfied with the outcome, your work is still not complete. You must get your image ready for presentation. A nice image, well matted, looks good, and a good print gets to the final stage though its presentation. Framing becomes the final task. Even good matting can elevate a work to a new class. This chapter will cover presentation techniques while mainly focussing on matting as the core presentation form.

9.1 Presentation options

Showing your prints from a box of images is not really what we would consider *presentation*. Here are some of the most common options:

- Portfolio binders
- Portfolio books
- Portfolio cases with matted prints
- Single matted prints
- Final framed prints

Except of the first, all of these presentation options require that you mat your prints.

9.2 Portfolio binders

There are many different kinds of portfolio binders available. If your portfolio binder looks cheap, it can make the whole portfolio look cheap. Also, plastic sleeves are available in different qualities. Some are kess transparent than others. Sleeves protect portfolio prints, but can also distract from their true quality with milky plastic or light reflections from the sleeves.

For galleries, you want the best quality binders (expensive), and also you want make a suitable layout for your portfolio prints. Here, some of the digital tools for Photoshop simulating frames, can be a good place to start. In the end, you have to come up with a signature layout fitting your own work. All materials for portfolio binders need to be archival (acid free, will not yellow, …).

Here are some brands we use:

- **Itoya Art Profolio Evolution** ([69]): Cheap and simple. Adequate to store images. Probably not the correct choice to show a gallery, however.
- **Prat** ([70]): Higher-end portfolios. Quite expensive.

9.3 Matting

True matting

The most common form of fine art print presentation is matting. While there are many different styles of matting, we cover some methods commonly used by fine art photographers.

Note: All materials should to be archival (P.A.T.-certified)!

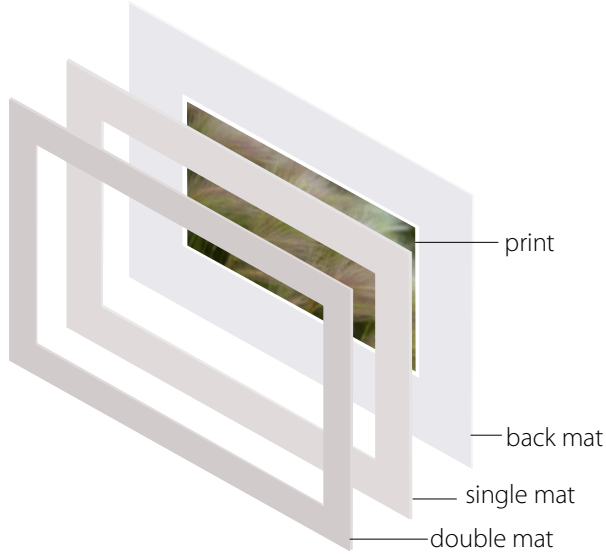


Figure 9-1: Principle and terms of matting

- **Back Mat**: This can be normal mat board or archival foam board.
- **Mats**: The two principle styles are *single matting* and *double matting*. We (Uwe Steinmueller) use mainly single natural white mat boards.

More on mats:

- Museum boards are 8 ply thick (used often for B&W matting)
- Most boards are 4 ply (used by us)
- Need to be archival (we remind you more than once)
- Come in many colors (we prefer simple natural white)
- You need a mat cutter, buy precut mats or order board from a mat cutting service. Remember that blades need to be sharp. Otherwise they make ragged corners. Change blades often!

The principle matting process

- Always print pictures with white borders at least 1" wide.
- Use heavy paper so that your photos don't curl. De-curl prints if needed. We use mostly papers of 250–350 grams trying to use sheets which avoid curling from the beginning.
- The first step is: To mount/hinge the print onto the back board. We hinge the print to avoid heat or other side effects of glue. Thin or large prints need to be cold-/heat-mounted. It is suggested testing to see how your paper behaves We will show later a prodedure to hinge a print.
- Cut the first mat and place it on top. Here are two principle strategies for cutting the top opening in a mat.
  #1: Have the mat opening wide enough to show white paper and a possible signature (you may prefer to tone the paper to better match the mat).
  #2: The mat hides all the white border of the print.
- Optional: Cut a second matte if you prefer double mats.

Matworks! helps with your calculations

For the PC, there is a helpful free program by Giorgio Trucco called *Matworks!* ([71]) which can help you with the calculations of mat openings:

Figure 10-2: Matworks! (Yes, the "!" is part of the name)

You enter the following values:

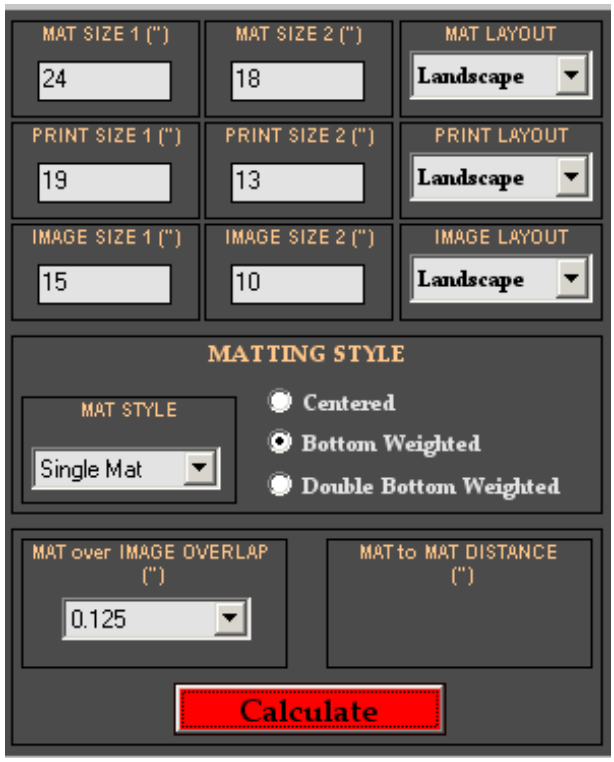


Figure 9-3: Matworks! input data

- **Back-mat size**: Here, 24×18″
- **Size of the print paper**: Here, 19×13″
- **Print size**: Size of the actual print on paper you want to show. For our example, it is 15×10″.
- **Mat Style**: Here, *Single Mat*
- **Weighted or centered**: *Weighted* means that you make the bottom border larger than the top border. Centered will keep both the same. Which to use is largely up to your personal taste.
- **Mat over image overlap**: Can be positive and negative. When positive, it covers part of the actual image. If negative, it reveals some part of the white border (consider tinting during printing to match the mat color). Revealing a border has some advantages, as it allows you to write a signature on the paper and make it visible.

When you hit Calculate, Matworks! calculates all the placements and openings:

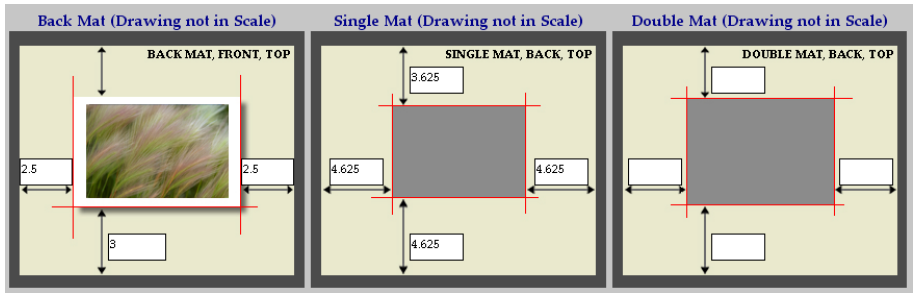


Figure 9-4: Matworks! output

Matworks! is very helpful when cutting with a standard mat cutter where you mark openings on the back of a board with a pencil. This next section describes a sample session using a professional mat cutter and more advanced matting techniques.

A mat cutting sample session

We show here a sample session, where we followed the very well known master printer Charles Cramer in his studio. Charles showed us how he mats pictures using one of our prints from an HP Designjet 90:

- **Paper size**: 13×19″
- **Print size**: 10×15″
- **Mat size**: 18×24″. We advise using standard mat sizes: 11×14″, 16×20″, 18×24″, 24×30, … This way, the mats match readily available frames. Of course, there are situations where you will want to deviate from these standard sizes.
- Single matting

Matting step-by-step

We mention again that all materials are archival!

1. Cut two 18×24″ mat boards (same material).
2. Place the print onto the back-mat (centered or weighted) and secure it in place using post-it notes.

3. Mount/hinge the print to the back-mat. Charles uses a so-called *T-hinge*:

Figure 9-5:
Transparent tape mounted to the back of the print (glue toward the top)

Note: For the HP satin paper, we may glue the print at the top of the paper, since the back is very rough and may not hold the tape that securely.

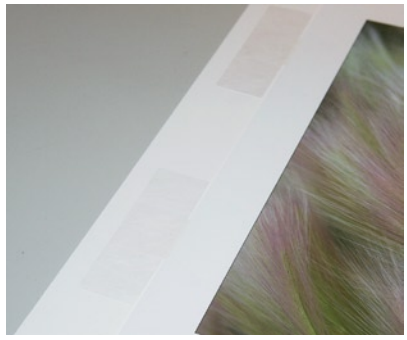


Figure 9-6:
Use tape to hinge the transparent tape to the back-mat

4. Add protective photo corners.

Figure 9-7:
Stabilize the print with photo corners

5. In fact, these corners do not actually hold the print, leaving room for a print to move (heat, humidity). The corners serve the purpose of helping the print during transport, so that there is not

excessive tension on the T-hinges.
Measure the opening of the single mat.

Figure 9-8: Measuring

Now, we are ready to cut the mat. Charles uses a 60×40" Speed-mat cutter (Uwe has a 32×40" model, These mat cutters are expensive, but make cutting mats more fun. Additionally, wall-mounting helps considerably in saving space):

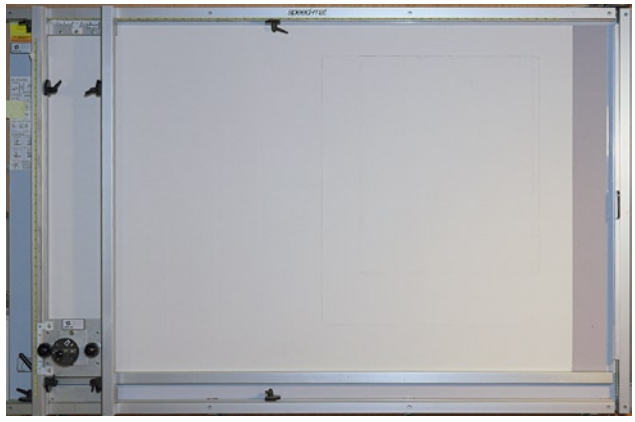


Figure 10-9: Speed-mat cutter

With the Speed mat, it isn't necessary to mark the opening on the back, as you can set all four corner stops of the Speed-mat itself. You then insert the mat board, and cut all four sides without changing the mat board position.

6. Smooth the cuts with a burnishing bone.

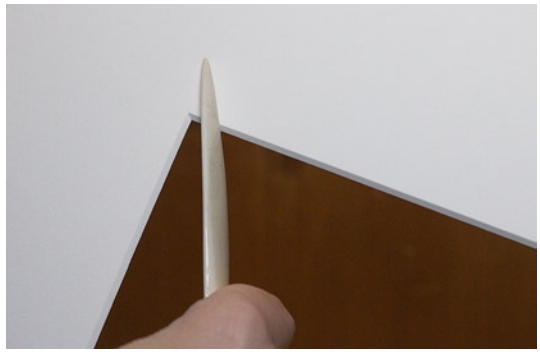


Figure 9-10: Smoothing using a burnishing bone

7. Sign the print if you wish.

Figure 9-11: Signature on the print

We sign both the print (in case it would be re-matted in the future) and on the mat because, in this case, we will cover the white border with our mat. Of course, use pigment ink pens that are archival.

8. Combine back-mat and mat with tape.

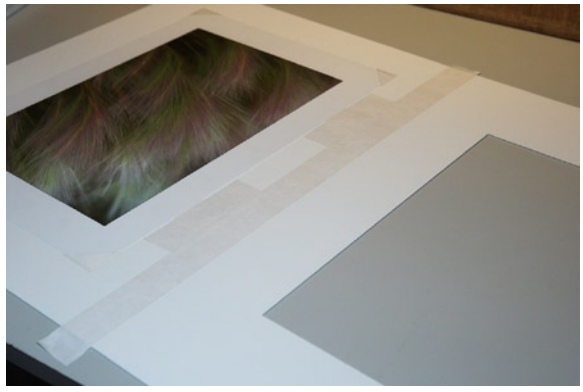


Figure 9-12: Combine back-mat and mat

9. Sign on the mat. We prefer a normal soft pencil for the signature on the mat.

Figure 9-13: Signature on the mat

These steps are not really difficult, but you must pay close attention to all the small, yet important, details.

Faux matting

When we talk about 'faux matting,' it means we do not use a separate mat but, rather, print a mat-like image together with our original print. This quite naturally is not of the same quality as a true mat, but in some cases, may be totally adequate. When using a good faux mat, you may have to look closely to see the difference. If you frame a print using a glass cover, a disadvantage of faux matting is that the faux mat will provides no separation between your print and the glass. A print touching the glass is a bad solution.

'Faux mats' can be created in Photoshop or other drawing programs. There are specialized Photoshop plug-ins for this purpose (e.g. QuickMats 3 by John Hartman [73] – but for $ 239, may be too expensive for most users). A cheaper way is to use ShutterFreaks 'Photoshop Frames for Printing' at about $20 (see [74]). This is a set of actions for creating frames and mats within Photoshop.

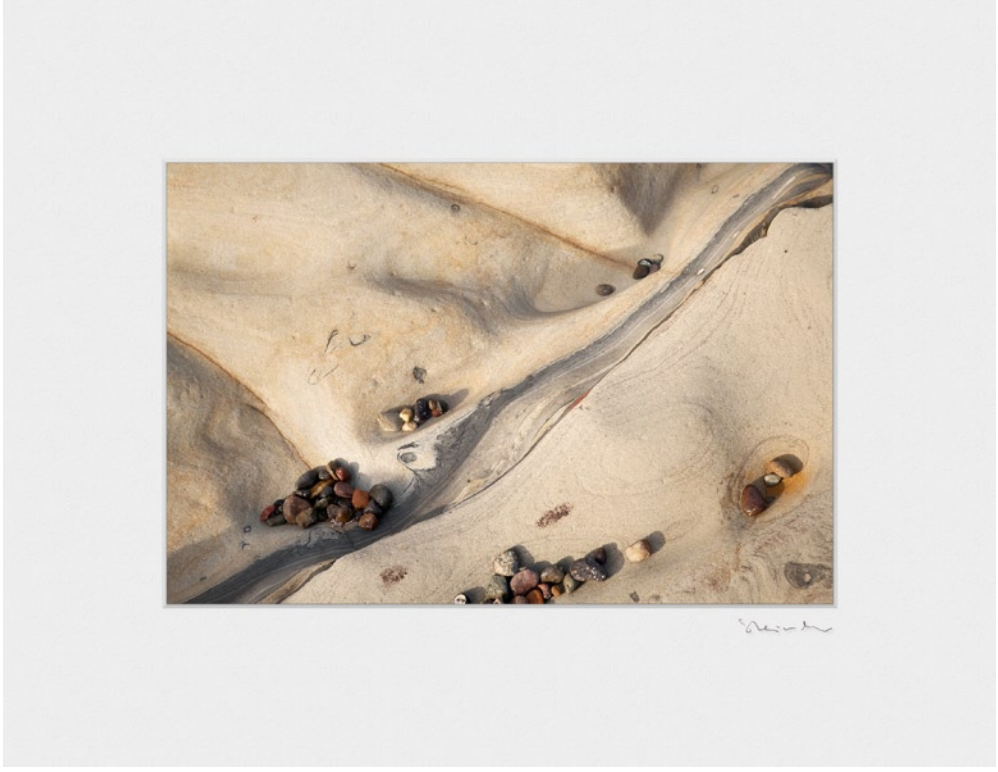


Figure 9-14: This 'faux' matting was done using QuickMats 3

An advantage of faux matting is that you may easily use a mat color that matches some color in the image. To do this, pick a dominant color from the image and use it as the mat background color. In most cases, you get an even more appealing mat if you reduce the saturation of this color to a suitably lighter color.

9.4 Framing

For optimal permanence, it is advisable to frame pictures using a glass or acrylic cover. This not only helps to present an image in an appealing way, but also protects it from dust and other kinds of contamination. Glass and acrylic – also called 'Plexiglass' – also partly filters destructive UV components of light (partly by reflecting it). Additionally, they very much reduce air flow over the print thus reducing the bleaching affect of air pollutants, such as ozone.

Like matting, aspects of framing are a question of personal taste, and there are literally thousands of different types of frames. For this reason, we want to focus only on basic techniques and not into questions on the type of frame.

The normal process involves:

1. Attaching the print to a backing board
2. Overlaying the attached print with a mat – if one is used. This is done using archival-quality framing tape.
3. This sandwiched package is now covered (at least we recommend this) by an acrylic or glass front panel and mounted into the frame.
   To improve the UV-filtering function of your glass or Plexiglass, use museum-quality. This may filter up to 99 % of the UV spectrum of light, but is substantially more expensive (2–4 times as much) than standard glass or acrylic.
4. Tape this sandwich into the actual frame – again using archival-quality tape.
   Alternatively, the backing board, print, mat and glass front sandwich is fixed into the frame with spring clips on the back of the frame. Here, however, we also recommend adding a tape on the back creating an (almost) airtight package.

If you print on canvas rather than paper, you should mount the canvas on a board or use artist stretcher bars.

Frames come in many forms, materials and sizes. Concerning the material, make certain that it is acid-free, and if longevity of the print is an issue, that all parts of the frame coming in contact with the print do not chemically interact with the print.

Concerning costs, it is advisable to stick to one of the numerous standard frame sizes (e.g. 8 x 10, 11 x 14, 16 x 20, …). One disadvantage of this is that those sizes do not match printing industry paper sizes. This is no real problem if you use a larger sized frame and a mat matching that size. However, the aspect ratio of most frames differ from those of photos shot with today's digital cameras (which is either 3:4 or 2:3), or even with traditional 35 mm film format (which is 2:3).

Here are further points you should have an eye on when framing a print:

- Give your print ample time to dry before you frame it. We consider 24 hours a minimum, but prefer 2–3 days.
- **All** material used must be archival-quality (acid-free, lignin-free). This applies to backing boards, mats and adhesive materials – even the paper used to seal the print against dust and airflow at the back of the print. If you want to be sure that your material is conservation-quality, look for material that has a P.A.T. certification.
- If you use a wooden frame, do not let your print touch the wood (wood contains some acid and lignin), but isolate it from the wood using buffer paper.
- Never let the print touch the glass, as some inks or coatings can react with the glass or permanently stick to it. Should condensation occur, water on the glass could damage the print. Either use a mat or a frame spacer to provide sufficient print clearance.

If you have little demand for quantities of frames, it is advisable – and often less expensive – to use the service of a framing shop. They can provide you with standard-sized, as well as custom-sized frames. When you require print longevity, tell them clearly that you expect archival-quality materials to be used.

There are not only many different kinds of frames, but there are also many more ways to mount a print. Mounting prints on foam or fiber

boards or even aluminium boards is an alternative giving a print a more modern touch. Foam boards are available in various sizes and thicknesses from art supply vendors. They may even very easily cut down to your favorite size with a sharp knife or a mat cutter.

*Figure 9-15: Print cold-mounted on a aluminium board (top) and frame mounted (bottom) result in different impression (prints: **Gottfried Hüttemann, Germany**)*

When you mount a print on a board, a borderless print (or cut down to become borderless) will probably work best. A mounted print with no glass cover may reproduce the colors better than a prints with a glass cover with standard glass as standard glass may give your print a more bluish appearance (see figure 9-15 lower image). You may prevent this using (more expensive) special glass.

There are several ways of mounting the prints:

- Hot mounting techniques
- Cold mounting techniques
- Spray mounting

As mounting requires some experience, it should be left to a photo service, a frame shop or a bookbinder. Only if you intend to mount many prints, the investment in tools and the time to learn mounting is worth the expense.

9.5 Coating

With canvas-based prints, often no frame is used at all – or no glass/acrylic cover. In this case, it is recommended covering the print with a protective coating. The same is true when mounting a print on foam board or other kind of board to display it with no covering at all. For prints presented outdoors, coating is an absolute must (but not further discussed here).

There are two specific problems with coating:

1. There are only few coatings an the market that have a proven record for being truly archival (conservation-quality).
   One product, recommended by several photographers and having a test certificate by WIR, is PremierArt Print Shield ([76]). It's offered as a spray, as well as a liquid that may be rolled or otherwise applied to prints.
2. The coating will, to some extent, influence colors. For this reason, if color confidence is an issue, you should use an ICC profile based on a coated print. Do your print on your preferred paper, coat it and then profile this combination.

When coating, be sure the coating is suited for the kind of ink and the type of paper surface used with the print. Some coatings are only suited for dye-based inks, while only a few coatings are suited for matte or semigloss prints.

There are several ways to apply the coating – e.g. with a brush or a roller (we prefer a foam roller) or by spraying. Applying the coating with a brush or a roller allows giving the surface a somewhat artistic

special touch – if this is suitable. In any case, it must be done very carefully; a very clean environment while avoiding dust like the plague. Still, there remains a real risk of spoiling prints when coating. It is important to test your coating method and get some experience while using a scrap print. Very carefully clean your print before coating making certain it is solidly dry (at least one day after printing).

When framing a coated print, also give the coating ample time to dry before framing or storing.

When working with sprays, wear a face mask, goggles and gloves, and only work in a well-ventilated area. Also be sure you work in a temperature of about 64–77° F (18–25° C).

9.6 Laminating

Another way of protecting a print is with lamination. This effectively seals the entire print from humidity, soiling and air pollutants. With pigmented inks, it also provides a highly homogeneous gloss. In theory, it should also improve lightfastness. There are some studies, however, that show that this is not the case with quite a few prints that have been laminated in the past – even using high quality techniques of some museums. The other disadvantage seen is hat laminated prints, in our estimation, have a quite *plasticky* look.

As high-quality laminating requires special laminating tools, you should ask a print shop to do this. You wouldn't use those office laminating machines, would you?

9.7 Put your print in its true light

Light is a dominant factor when shooting a photo. It is an important factor, as well, when presenting a photo (print), as the impression of an image is very much influenced by its lighting. As said previously, digital color management assumes that 'Daylight 50' (D50) is used for image viewing (image inspection). Prints produced by our inkjet driver (or any other color-managed printing technique) are tuned to look right (actually present the correct colors) with D50. Using different lighting may lead to metamerism and slightly incorrect colors. Metamerism is an effect where two colors appear the same in one type of lighting but look different in another (or vice versa). How

important the metamerism effect is may depend on the inks used, the ink mix used, the weaving pattern (dithering) used and other factors. But even when there is no noticeable metamerism, colors do change with different lighting.

The lighting also may have effect on the longevity of a print. As mentioned in chapter 2, the more energy the light has, the more destructive it is. Thus intensity, as well as color spectrum are factors to be considered. Brighter light results in a faster fading. Shorter wavelength (a higher ultra-violet) components will do the same.

Galleries and museums know this and take special care by choosing their lighting very carefully. If you sell your prints, your customer may not know this or may not care about it. If you hang your own prints or consult a customer, the following advice may be helpful.

First let's have a look a different typical lighting characteristics:

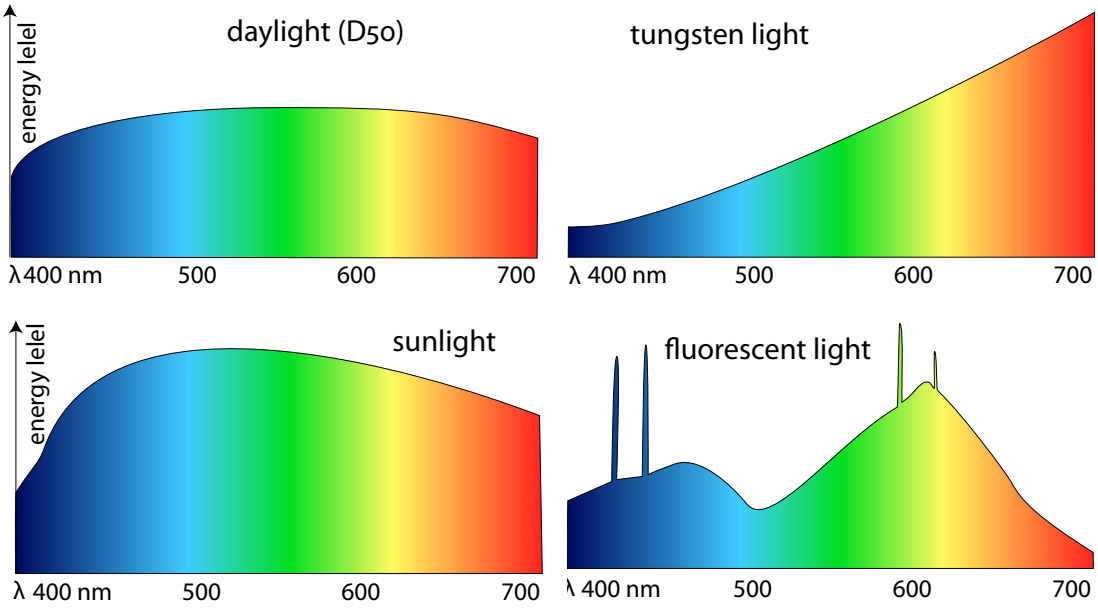


Figure 9-16: Light spectrum characteristics of different typical lightings

The images of figure 9-14 should make it obvious, that the image impression changes in different lighting. The best continuous spectrum is supplied by daylight, which also is the reference. Fluorescent light is clearly the worst of these mentioned (there are still worse lighting conditions – for example, metallic halide lamps (mercury lamps). Thus, it is advisable to use 'daylight-like' lighting. As in most rooms you will not get away with actual daylight – which naturally changes through the day – you have to use lamps.

There are several companies selling 'daylight lamps' (e. g. SoLux [54] and Ott-Lite [55]). Some claim their 'daylight' is better than others – meaning that they claim a more uniform light spectrum and thus are closer to ideal daylight. For more on this, see chapter 9.1. Spot lights usually allow for optimal lighting of a picture. Here, halogen systems using a UV filter provide a warmer, more natural looking lighting than white fluorescent lamps that, in most cases, give a rather cold and dead light.

Use an adequate light intensity for print illumination at about 150–400 lux. This is about the average office lighting level. You may measure this using a good traditional light meter – preferable a digital one.

9.8 Albums

Storing prints in albums is a common way to archive and when unable to hang your prints, may be a better way of storage than archive boxes, particularly if you want to show them frequently. If print permanence is an issue, you should use albums that are acid- and lignin-free and buffered. Album plastic protection sheets should not be made of polyvinyl or cellophane, but of either polyethylene, polystyrene or polypropylene.

Using a slipcase for you album will provide enhanced protection against dust and light, thus increasing the longevity of the content.

*Figure 9-17: Albums/portfolios with direct printing onto the album pages (Courtesy of **Monochrom [36]**)*

The hinging of a print on an album sheet is a pain. For that reason there are several companies offering printable album sheets made

of high quality inkjet paper. These sheets usually are punched and may be added to the album by opening the screws of the album and adding the pages. You may find albums of this kind up to a size of 19.3 × 25.6 inch (49 × 65 cm).

9.8 Storing prints

Most of that which applies to traditional photos also applies to digital prints. For optimal longevity, store them in a dark, dry (relative humidity of 25–35 % would be optimal) environment and as cool as possible. (There are even specialized sub-zero cold storage systems for longtime archiving of valuable prints – see [61] for essays on this topic). When possible, avoid temperature and humidity cycles. If you use a closed, air-tight container, you may add silica gel packages to absorb superfluous humidity. Flat, horizontal storage should be your preference.

Figure 9-18: Use closed archiving boxes with buffered materials (P.A.T certified) for storing your prints (Courtesy ***Monochrom [36]).***

Protect them from light, dust, high humidity, atmospheric contaminations and from physical damage. This is best done by using envelops or protective sleeves. The sleeve, envelope as well as the container (e.g. an archive box) or album all should be acid- and lignin-free and buffered. Regular PVC-based envelopes or sleeves should be avoided. As with framing, use P.A.T.-certified materials if feasible.

Glossary / Abbreviations

absolute colorimetric • See *rendering intent*.

ACR • see *Adobe Camera Raw*.

Adobe RGB (1998) • A color space defined by Adobe. It is well-suited for digital photographs and has a reasonably wide gamut, larger than sRGB, and includes most printable colors.

artifacts (or artefacts) • An undesirable effect visible when an image is printed or displayed, such as moiré patterns, banding or compression artifacts. Compression artifacts (JPEG artifacts) may result from too severe JPEG compression. Also over-sharpening may produce artifacts.

banding • Noticeable tonal level jumps in an area, where a continuous tone level would normally be. Banding is one type of *artifact*.

black point • The density (or color) of the darkest black a device may reproduce. Black levels beyond that are clipped to the black point.

bronzing • Some inks (usually black inks) have a reflective property resulting in a slightly bronze appearance under certain lighting conditions. This should not be confused with *metamerism*.

calibration • Adjusting the behavior of a device to a pre-defined state. Calibration, in many cases, is the first step when *profiling* a device.

caliper • refers to the thickness of a sheet of paper expressed in thousandth of an inch.

camera RAW format • See *RAW*.

candela • Unit of measurement for luminosity. Luminosity is specified in candela per square meter (**cd/m²**).

cd • See *candela*.

CF • ***C****ompact* ***F****lash* – a type of data storage used in memory cards for digital cameras.

CIE • ***C****ommission* ***I****nternationale de l'****E****clairage*. This is the international scientific organization which defined the CIE Lab standard.

CIE LAB • See *Lab*.

characterization • See *profiling*.

CMM • ***C****olor* ***M****atching* ***M****odule* – the internal color engine of a color management system. It does the color translation from different (source) color spaces to the PCS (***P****rofile* ***C****onnection* ***S****pace*), and from the PCS to the output color space. Well known CMMs are Apple's *ColorSync* for the Mac and Microsoft's ICM as an integral part of Windows. Adobe provides its own CMM module with applications, such as Photoshop and InDesign. It is called ACE (***A****dobe* ***C****olor* ***E****ngine*).

CMS • ***C****olor* ***M****anagement* ***S****ystem*.

CMYK • A color model based on the four primary printing colors *cyan*, *magenta*, *yellow* and *black* (**Black is also called the** *key color, thus K*). Used in print production, they

form a subtractive color model. Though many inkjet printers use CMYK inks (and often more additional colors), they, in fact, present an RGB interface to the user.

CRT • Cathode Ray Tube – a component in monitors utilizing glass tubes for display.

clipping • The loss of certain tonal values usually found in the color or tonal limits of a color space. Clipping occurs, for example, when converting images from 16-bit-mode to 8-bit or when converting from RGB to CMYK. In these cases, usually some saturated colors are clipped to become less saturated colors.

color gamut • See *gamut*.

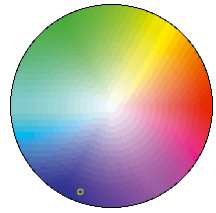
colorimeter • An instrument used to measure the color of emitted light. Often one is used while profiling monitors.

color model • The way colors are described by numbers. RGB, for example, uses a triple, denoting the amount of red, green and blue. CMYK uses a quadruple for the percentage of cyan, magenta, yellow and black. There exist other colors models, such as Lab, HSM, Grayscale (a gray value) or Bitmap (with pixel values of 0 or 1 – white or black respectively).

color space • A range of colors available for a particular profile or color model. When an image resides in a particular color space, this limits the range of colors available to that image. It also defines *how* the color values of an image are to be interpreted. There are *device-dependant color spaces* (e. g. that of a scanner or printer) and *device-independent color spaces* (e. g. Lab, Adobe RGB (1998) or sRGB).

ColorSync • Apple's implementation of ICC-based color management (part of Mac OS 9, as well as, Mac OS X).

color wheel • A circular diagram displaying the available color spectrum (at a particular brightness level).

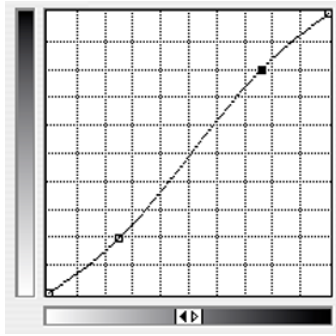


color temperature • A measure on the spectrum of the wavelength of white (light). The unit used is Kelvin (K). Lower color temperatures correspond to a red or yellowish light, higher temperatures result in a bluish tint. The term 'temperature' stems from a 'blackbody radiator' emitting (white) light when heated to a specific color temperature Here are some examples:

candle light, fire	1 000–1 800 K
tungsten	2 600–2 700 K
halogen lamp	3 400 K
moonlight	4 100 K
D50 daylight illuminant	5 000 K
sunny and blue sky	5 800 K
D65 daylight illuminant	6 500 K
flash	6 500 K
cloudy sky	7 000–8 000 K
neon light	8 000–9 000 K
sunny mountain snow	up to 16 000 K

chroma • The technical term for *saturation*.

curves • A tool in Photoshop that allows control (change) of tonal values in an image. The curve diagram below represents the relationship between input and output. By modifying this curve, corresponding tonal values of the pixels in the image are changed.



CS1, CS2 • Adobe Creative Suite 1 & 2. The full suite includes Photoshop, InDesign, Illustrator, GoLive and Version Cue. The Premium suite includes Acrobat. CS2 also includes Bridge.

D50 • Daylight at 5,000 Kelvin. This is the standard light (*illuminant*) in the printing industry (prepress) for evaluating colored prints.

D65 • Daylight at 6,500 Kelvin. This is the standard (*illuminant*) that is closer to the light emitted by CRT or LCD monitors.

device profile • See *ICC profile*.

dithering • A technique used to simulate many different colors and/or halftones yet utilizing only a few primary colors by placing dots in a certain pattern. Viewed from an appropriate distance, the image is perceived as a continuous tone image.

Dmax • specifies the maximum of a density range of a scanner, a slide or a print. Density range is the difference in density between the lightest and the darkest areas of an image.

dot gain • Halftone dots grow slightly in size when printed (e.g. due to ink spreading). This is called *dot gain*. Coated paper has a dot gain of 8–20 %, while with uncoated paper it may grow up to 28 %. Photoshop may take dot gain into account when producing output for printers by reducing a dot size appropriately to compensate for its future dot gain.

DPR • ***D**isplay **P**ermanence **R**ating* – a time period a print should last before a noticeable fading of the image takes place. For comparable figures, you must know under what conditions this measurement took place.

dpi, DPI • ***d**ots **p**er **i**nch*. Used as a measurement of print resolution in regard to ink or toner dots per inch on paper or printing plates. Most printing techniques (e.g. inkjet printers or offset presses) simulate a halftone value or a non-primary color of a pixel using a pattern of tiny dots. With such printing techniques, the dpi value of a printing device must be considerably higher (by a factor of 4 to 8) than the *ppi* (*pixel per inch*) value of the image.

ECI • ***E**uropean **C**olor **I**nitiative*. This organization focuses on defining standardized means to exchange colors (color images) on the basis of ICC profiles. You may find some specific color profiles at their Internet home page (see www.eci.org).

ECI-RGB • An RGB work space for those images destined for prepress work in Europe. Its gamut is somewhat wider (slightly more green tints) than that of Adobe RGB (1998) and also covers nearly all colors intended to be printed.

EPS • ***E**ncapsulated **P**ost**S**cript*. A standard file format for graphics, usually those including vector graphics or a mix of vector graphics and bitmap images. Often, EPS files contain both the actual graphic information and, additionally, a preview image of that graphic.

EV • *Exposure Value.*

Exif, EXIF • A standardized format for camera metadata (e. g. camera model, exposure value, focal length, …). This data is usually embedded in the image file and may be used for searching, as well as, by applications to act in an intelligent way on the data. PTLens, one example, uses the focal length value from EXIF data to correct lens distortions.

Firewire • (IEEE 1394) a fast, serial interface for cardreaders, digital cameras, scanners and other peripheral devices. Firewire allows for transfer rates of up to 40 MByte/s (1394a) or 80 MByte/s (1394b).

gamma • (1) Relationship between tonal values (or input voltage with a monitor) and perceived brightness. There are two gamma values in broad use:
(A) 1.8, the Apple standard for the Mac and preferred in prepress work.
(B) 2.2, the Windows standard. For photographs, we recommend using 2.2, (even on Macintosh systems) when it comes to monitor calibration and profiling.
(2) The degree to which a *color space* or device is non-linear in tonal behavior.

gamut • The total range of colors (and densities) a device can reproduce (e. g. a monitor or printer) or capture (e. g. a scanner or digital camera). *Color gamut* is the range of colors a device can reproduce (or capture) and *dynamic range* refers to the brightness levels a device can produce or capture.

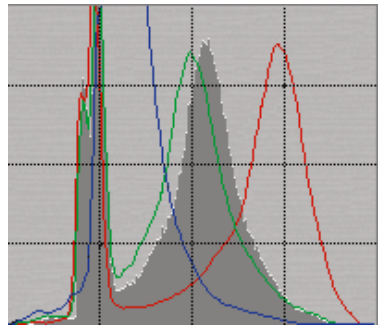
gamut mapping • The way colors are remapped when an image is converted from one color space to another. If the destination space is smaller than the source space, color compression or color *clipping* will be take place.

gray balanced • A color space is called *gray balanced* if equal values of the *primary colors* result in a neutral gray value. This situation is preferable for work spaces.

gsm • ***g****ram per* ***s****quare* ***m****eter* (g/m²) – a measurement (*grammage*) for the paper weight.

highlights • Areas of an image with no color or gray level at all.

histogram • A visual representation of tonal levels in an image. With color images, it is advantageous not only to see luminance levels but also tonal levels of each individual color channel:



HSB, HSL • Adaptions of the RGB color model. Colors are described by a ***h****ue*, ***s****aturation* of the hue and ***l****ightness* (HSL) or ***b****rightness* (HSB).

hue • Hue is normally referred to as *color tint*.

ICC • ***I****nternational* ***C****olor* ***C****onsortium*. A consortium of companies that develop industry-wide standards for color management – e. g. ICC profiles. For more information see www.color.org.

ICC profile • A standardized data format to describe the color behavior of a specific device. ICC profiles are the basis of color management systems. They allows CM systems to maintain consistent color impres-

sion across different devices, different platforms and throughout a complete color-managed workflow.

ICM • ***I**mage **C**olor **M**anagement* or *Integrated **C**olor **M**anagement* – the Microsoft implementation of the color management module in Windows.

IPTC • ***I**nternational **P**ress **T**elecommunication **C**ouncil*. In photography, IPTC is a metadata format describing the image. It provides fields, e.g. for copyright notices, rights usage terms, a title (caption) and keywords.

intent • See *rendering intent*.

IT-8 • A family of standard targets used by profiling devices, such as scanners or digital cameras.

JPEG • ***J**oint **P**hotographic **E**xperts **G**roup*. This ISO group defines a file format standard for color images. The JPEG format uses lossy compression, offering various tradeoffs between high quality (at lower compression) and lower quality resulting in a higher compression but smaller files.

Lab, LAB, L*a*b*, CIE LAB • A perceptual-based color model defined by the *CIE*. Colors in this model are defined by L (***L**uminance*) and two color components, **a** and **b**. 'a' (or 'A') is the axis ranging from red to green while 'b' (or 'B') ranges from blue to yellow.

LCD • ***L**iquid Crystal **D**isplay*. A display technique used for flat panel monitors (TFT monitors).

lpi, LPI • ***L**ines **p**er **I**nch*. The measure used to define printing resolution (or screen frequency) with typical halftone printing methods, such as, offset printing.

luminance • Amount of light (energy) emitted by a light source, e.g. by a monitor. The unit used with monitors is *candela per square meter* (cd/m^2).

lux (lx) • Unit for measuring the illumination (illuminance) of a surface. 1 lux = 1 lumen/m^2, 1 lux = 0.093 foot candle.

metadata • Data describing other data objects. EXIF and ITPC data are examples of metadata as part of digital photographs.

metamerism • The phenomenon that two color samples composed of a different mix of primary colors may look the same (produce the same color sensation to a viewer) with some lighting and may produced differentiated color sensations when viewed under a different lighting.

mil • Measurement of thickness, especially in paper. 1 mil = 1/1000 inch = 0,0254 mm.

P.A.T. • *Photographic Activity Test*, a testing standard (ANSI NAPM IT9.16-1993, ISO 14523-1999, DIN ISO 9706) for material in archiving and preservation. Material with a certificate to be PAT-compliant should show a good longevity and should be well suited for archival and museum usage.

PCS • ***P**rofile **C**onnection **S**pace*. This is an intermediate color space used when converting colors from a source space to a destination space (say, from one profile to another). According to the ICC specification, it can be either *CIE-Lab* or *CIE XYZ*.

perceptual intent • See *intent*.

ppi, PPI • ***p**ixel **p**er **i**nch*, used to specify the resolution of a digital image. See also *dpi*.

primary colors • Those colors of a color model used to construct the colors of the pixels. For RGB, the primary colors are red,

green and blue. CMYK primaries are cyan, magenta, yellow and black.

profile • See *ICC profile*.

profiling • The act of creating a device *profile*. Usually a two-step process, whereby the first step is to linearize the device. The second step measures color behavior of the device and describes it with an ICC profile. The entire process is also called ***characterization***.

PS • ***P****hotoshop*.

RAW (camera RAW format) • See *ICC profile*.

RC • ***r****esin* ***c****oated paper*, used for photographic prints in the wet darkroom, as well as, for inkjet prints

relative colorimetric • See *rendering intent*.

rendering intent • A strategy to achieve color space mapping when converting colors from a source to a destination color space. ICC has defined four different standard intents:
(1) ***Perceptual*** compresses colors of the source space to the gamut of the destination space (where the source space is smaller than the destination space). This is the intent recommended for photographs.
(2) ***Relative colorimetric*** does a 1:1 mapping when the colors in the source space are all present in the destination space. Out-of-gamut colors of the source are mapped (clipped) to the nearest neighbor of the destination space. This intent may be used for photographs if most of the colors in the source space are available in the destination space. In this instance, most colors of the source are mapped 1:1 into the destination. The *white point* of the source space is mapped to the *white point* of the destination space, as well.
(3) ***Absolute colorimetric*** does a 1:1 mapping when colors in the source space are present in the destination space. Out-of-gamut colors of the source are mapped (clipped) to the nearest neighbor of the destination space. The *white point* of the source is maintained. This intent is used (only) when *soft proofing*.
(4) ***Saturation***. This intent aims to maintain saturation of a source color, even when the actual color has shifted during mapping. This intent may be used when mapping logos and diagrams, but is not suitable for photographs.

resolution • This term defines the depth of detail an image can reproduce. Resolution is measured in dots per inch (*dpi*) or pixels per inch (*ppi*).

RGB • ***R****ed,* ***G****reen,* ***B****lue*. These are the primary colors of the standard additive color model. Keep your photographs in RGB mode as long as possible, and use RGB for archiving your images.

RH • ***R****elative* ***H****umidity in percentage*

RIP • ***R****aster* ***I****mage* ***P****rocessor*. A module, either part of a printer or a software application. The RIP converts page information into a raster image or dot pattern for printing.

saturation • (1) defines the purity of color. Saturation may vary from none (which is gray) via pastel colors (some saturation) to pure colors (full saturation) with no gray.
(2) One of the four rendering intents. See *rendering intents*.

spectrophotometer • An instrument to measure the color of emitted and reflected light. It usually is used when profiling printers and measuring the color (light spectrum) of a print or other surface.

soft proof • Usage of the monitor as a proofing device. For soft proofing, Photoshop simulates colors an image will have with a different output method (e.g. a print) on a monitor.

sRGB • A standard color space for monitors. It is intended for images presented on monitors or on the Internet.

swellable paper • A kind of coated paper used for dye-based inks. Here, when the moist ink hits the paper, the paper swells up and lets the ink sink in (only into the top layer). When drying, the paper again closes up and encapsulates the ink particles.

tagged images • Images with an embedded color profile.

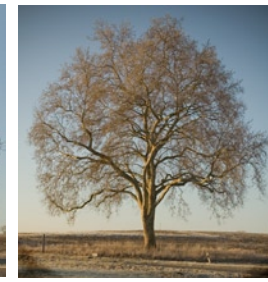
TIFF • ***T**agged **I**mage **F**ile **F**ormat*. A file format for images. TIFF acts as an envelope format for many different image formats and allows several different compression modes – most of them lossless (e.g. LZW, ZIP, Runlength encoding, uncompressed). It allows storing different color depths (from 1 to 32 bits per channel), embedded comments, profiles, and other metadata, as well as, layers and alpha channels. It is well suited as an archival format for images.

USB • Universal Serial Bus. A computer device interface for peripherals, such as card readers, cameras, scanners and external hard disks. There are two version of the USB bus, where USB 2 (high speed) is much faster (up to 60 MByte/s) than USB 1.x (up to 1.2 MByte/s).

USM • ***U**nsharp **M**asking*. A method of sharpening an image by increasing the contrast of its edge pixels. The term stems from a traditional film-composing technique.

vignetting • Vignetting is an effect where some areas of a photograph are less illuminated than others. Most camera lenses exhibit "optical vignetting" to some degree – mostly at the outer edges, but stronger when an aperture is wide open.
"Mechanical vignetting" may occur if a lens hood is too large or not properly attached.

slight vignetting



very strong vignetting

wide gamut RGB • A large color space that covers almost all of RGB. There is no physical device that can reproduce all color of *wide gamut*. This color space is sometimes used for archival purposes when output will be produced for photographic printers or transparent recorders.

WIR • ***W**ilhelm **I**maging **R**esearch Institute*. This is a well known research institute that evaluates the image permanence ratings of specific prints.

white balance • Adjusting the color temperature and color tints in an image, so that there is no color cast, and gray areas show no color tint.

white point • (1) The color of ›pure white‹ in an image. On a monitor, it is the brightest white the monitor can display. In photo prints, it usually is defined as the color of blank paper.
(2) The color of a light source or lighting conditions in terms of *color temperature*.
(3) The color "white" in a color space. For example, *Adobe RGB (1998)* and *sRGB* have a

white point of 6,500 K (*D65*) while *ECI-RGB, Color Match RGB* and *Wide Gamut RGB* have a white point of 5,000 K (*D50*). Most CMYK color spaces have a white point of D50.

white point adaptation • When a color mapping takes place and the source and the destination spaces have different *white points*, with some *intents* (e.g. *Relative colorimetric*) colors are adapted relative to the new *white point*.

WIR • *Wilhelm **I**maging **R**esearch* is the standard reference for ***D**isplay **P**ermanence **R**atings* for digital images.

working space • A device-independent color space (profile). It defines the color *gamut* available to the image using this working space. For photographers, *Adobe RGB (1998)* or *ECI-RGB* (in Europe) are the recommended working spaces.

Resources

Camera: Nikon D100

B.1 Recommended Books

[1] Tim Grey: *Color Confidence. The digital photographer's guide to color management.* *Sybex Inc, San Francisco, 2004.*

[2] Bruce Fraser, Ch. Murphy, F. Bunting: *Real World Color Management.* Peachpit Press, Berkeley CA, 2003

[3] Harald Johnson: *Mastering Digital Printing.* *Thomson, Boston, 2004.*

[4] Ben Willmore: Adobe Photoshop CS2 Studio Techniques. Adobe Press, 2005

[5] Uwe + Bettina Steinmueller: *California Earthframes* d.punkt Verlag, Heidelberg (Germany), 2005

[6] Katrin Eismann:
Photoshop Masking & Composition
Peachpit, 2005

B.2 Useful resources in the Internet

Remember that Internet addresses may change or vanish over time. We attempt, however, to keep up-to-date. In the e-book version, you can click on links (in blue) to get to a particular page directly with your browser.

[7] Uwe Steinmueller: Outbackphoto. This is Uwe's Internet page, full of up-to-date information on digital photography including lots of informative papers on photography:
www.outbackphoto.com

[8] *Colors by Nature* – some of the color works of Bettina & Uwe Steinmueller:
www.colors-by-nature.com

[9] Uwe Steinmueller: *A Profile for B&W conversion*:
www.outbackphoto.com/artofraw/raw_08/profile_BW.zip

[10] Digital Outback Photo: *Our Tonality Tuning Toolkit* (,):
www.outbackphoto.com/workflow/wf_61/essay.html

[11] Digital Outback Photo: Paper on sharpening:
www.outbackphoto.com/dp_essentials/dp_essentials_05/essay.html

[12] EasyS Sharpening Toolkit (,) :
www.outbackphoto.com/workflow/wf_66/essay.html

[13] Digital Outback Photo: Paper on noise reduction:
www.outbackphoto.com/dp_essentials/dp_essentials_04/essay.html

[14] Digital Outback Photo: An essay on printing insights:
www.outbackphoto.com/printinginsights/pi.html

[16] Paper on *Noise Ninja* – a noise removal tool (,):
www.outbackphoto.com/workflow/wf_25/essay.html

[17] Digital Outback Photo: An essay on *Workflow techniques using actions and filters in layers*:
www.outbackphoto.com/workflow/wf_19/essay.html

[18] Uwe Steinmueller: *Variation Toolkit* (,) :
www.outbackphoto.com/filters/dopf004_variations/DOP_Variations.html

[19] B&W-ramp: An image with B & W values to find out what the black-point and white-point of your printer are:
www.outbackphoto.com/booklets/resources/fap/

[20] Bettina & Uwe Steinmueller: DOP2000: *Digital photography workflow handbook*:
www.outbackphoto.com/booklets/dop2000/DOP2000.html

[21] Bettina & Uwe Steinmueller: DOP3001: *Photoshop Layers for Photographers*:
www.outbackphoto.com/booklets/booklets.html

[22] Uwe Steinmueller, Jürgen Gulbins: DOP3002: *The Art of RAW Conversion. Optimal image quality from Photoshop CS2 and leading RAW converters.* E-book on RAW conversion using Adobe Camera Raw, RawShooter Essentials, and other RAW converters: www.outbackphoto.com/booklets/booklets.html

[23] Uwe Steinmueller, Jürgen Gulbins: DOP3002RSP: *The Art of RAW Conversion using RawShooter Premium 2006. Optimal image quality from RawShooter Premium 2006 and Photoshop CS2.* E-book on RAW conversion using Adobe Camera Raw, RawShooter Essentials, and other RAW converters: www.outbackphoto.com/booklets/booklets.html

[24] Alain Briot: *The Art of Digital B/W #007. Take control of your black & white inkjet printing with Inkjet Control*: www.outbackphoto.com/artof_b_w/bw_07/essay.html

[25] ICC – International Color Consortium: www.color.org

[26] ECI – European Color Initiative www.eci.org

[27] GretagMacbeth: *ColorChecker* and several profile packages (e. g. Eye-One Match and Eye-One Photo): www.gretagmacbeth.com

[28] ColorVision: Color Management Tools (e.g. ColorPlus, Spyder2Pro, ProfilerPlus, PrintFIX, …)(,) : www.colorvision.com

[29] Monaco Systems (now part of X.rite): Color Management Tools (Profiling packages, e.g. Monaco OPTIX for monitor profiling and PULSE ColorElite for printer profiling): www.xritephoto.com

[30] ErgoSoft: ErgoSoft is focused on Large Format and Printing. The ErgoSoft RIP *StudioPrint* () is mainly for printing photos. Another useful component offered is ColorGPS for a very extensive profiling of inkjet printers: www.ergosoft.com

[31] Digital Domain Inc: *Qimage RIP* () and *Profile Prism* () – a profiling software for printers, digital cameras and scanners: www.ddisoftware.com
Profile Prism ().
ICC profiling tool for cameras and scanners. They sell printer and camera profiles, as well. www.ddisoftware.com/prism/

[32] *Microsoft Color Control Panel*: A small Windows XP utility to install and uninstall ICC profiles, set default profiles for devices and for the graphic display of ICC profiles: www.microsoft.com/windowsxp/using/digitalphotography/prophoto/colorcontrol.mspx

[33] Bruce Lindbloom: Information on *Beta RGB*. You may download the ICC profile of Beta RGB here, as well: www.brucelindbloom.com/index.html?BetaRGB.html

[34] Bill Atkinson: A test image for your printer:
www.jirvana.com/resources/printing/bills_lab_test_image.zip

[35] Jack Flesher: *Paper Upsizing in Photoshop*:
www.outbackphoto.com/workflow/wf_60/essay.html

[36] *Monochrom* – a German supplier of photographic material with a good web page and a still better printed catalog:
www.monochrom.com

[37] *Premier Imaging Products* offers a number quality digital fine art papers under the label *PremierArt*:
www.premierimagingproducts.com

[38] Hahnemuehle: A maker of fine art papers of various kinds. You also find some ICC profiles there for their papers for various fine art printers (e. g. Epson):
www.hahnemuehle.de/site/us/798/home.html

[39] Moab: A maker of fine art papers of many kinds. You will also find ICC profiles there for their papers and different fine art printers (e. g. Epson):
www.moabpaper.com

[40] *Tetenal*: A maker of inkjet papers of various kinds. Also have ICC profiles for their papers for different fine art printers (e. g. Epson):
www.tetenal.co.uk/acatalog/Downloads.html

[41] *Pantone*: Pantone not only offers color guides and color management software, but also third-party inks for various Epson printers and including ICC profiles for various papers:
www.pantone.com

[42] *Lyson*: Lyson offers third party inks for a range of Epson and HP, as well as, some Canon inkjet printers plus inkjet papers. For their inks and papers, they provide ICC profiles and descriptions of how to use them.
www.lysonusa.com

[43] *Inkjet-Mall*: This company offers a rich selection of fine art papers and inks:
www.inkjetmall.com

[44] *Pictorico* Ink Jet Media: The company offers a rich selection of fine art papers (including transparency film):
www.pictorico.com

[45] Piezography: The company produces several special B&W inks (e.g. 'Piezography Neutral K7') which achieve very fine B&W prints. Inks are sold online by stores like Inkjet Mall.
www.piezography.com

[46] *Bowhaus* is focused on B&W printing. It offers InkJet Control and OpenPrintMaker (RIP software):
www.bowhaus.com

[47] *Inkjet Art Solutions* sells inkjet printers, papers and inks for these printers:
www.inkjetart.com

[47] *Luminous Photo Corp:* They offer several inks sets for inkjet printing, including black ink sets for Epson printers. Luminous (using the label Lumijet) also offers archival inkjet papers:
www.lumijet.com

[48] IPI – Image Permanence Institute: This institute sprang from the Rochester Institute of Permanence and does research in digital image quality, light stability tests and in the right conditions for long-term storage of film materials and digital images (e. g. inkjet prints):
www.imagepermanenceinstitute.org

[49] Dry Creek Photo: An Internet page including much useful information and links on color management for photographers and various test-charts and hints on how to prepare an image for digital photo printing:
www.drycreekphoto.com
They also have a useful page for monitor calibration done without special hardware devices:
www.drycreekphoto.com/Learn/monitor_calibration.htm

[50] Arches Infinity: This company offers fine art papers of various kinds. Here, you also find ICC profiles for papers for several Epson and HP printers (e. g. Epson R800, R1800, 1280, 2200, 2400, 4000, 4800, 7600, 9600, HP 5000):
www.archesinfinity.com

[51] *Inkjet Mall* is an online shop for inkjet printers, inks and inkjet media:
www.inkjetmall.com

[52] *Mediastreet* – an online shop – offers inks and media for fine art printing. They also offer the 'Niagra Continuous Ink Flow System':
www.mediastreet.com

[53] Pictorico Ink Jet Media: The company offers a rich selection of fine art papers (including transparency film):
www.pictorico.com

[54] SoLux: Offers different lighting solutions for 'natural' light (close to D50):
www.soluxlicht.com

[55] Ott-Lite Technology offers several TrueColor daylight lamps, as well as, bulbs and tubes:
www.ottlite.com

[56] Altostorm Software: Altostorm Rectinliear Panorama™ ( ) corrects geometric image distortion:
http://altostorm.com

[57] Colorbyte's Software *ImagePrint* (,) is a Software RIP for fine art printing coming with a large library of profiles. They differentiate lighting under which a print will be displayed:
www.colorbytesoftware.com

[58] Roy Harrigton offers a fine RIP – the *Quad Tone RIP* (,) – dedicated to B & W printing:
www.quadtonerip.com

[59] *MIS Associates Inc* is an online shop for inkjet inks and media:
www.inksupply.com

[60] **Wilhelm Imaging Research Inc** (WIR). This institute conducts research on stability and preservation of traditional and digital color photographs and motion pictures.
www.wilhelm-research.com
See also:
www.wilhelm-research.com/pdf/HW_Book_758_Pages_HiRes_v1a.pdf

[61] WIR: *Sub-Zero Cold Storage for the Permanent Preservation of Photographs, Motion Picture Films, Books, Newspapers, Manuscripts and Historical Artifacts*:
www.wilhelm-research.com/subzero.html

[62] *WIR Display Permanence Ratings for Current Products in the 4x6-inch Photo Printer Category*:
www.wilhelm-research.com/4x6/4x6.html

[63] *Power Retouche* offers several photoshop plug-ins. One we sometimes use for color to B&W conversion is *Black & White Studio*:
www.powerretouche.com

[64] Clayton Jones: *Fine Art Black and White Digital Printing. An Overview of The Current State-Of-The-Art.*
This is a very informative page on B&W printing:
www.cjcom.net/articles/digiprn1.htm

[65] Outback Photo: *The Art of Digital B&W.* Here, you'll find a number of papers on B&White photography (conversion, printing, …):
www.outbackphoto.com/artof_b_w/index.html

[66] Uwe Steinmueller: *TheImagingFactory: ConvertToBW Pro 3.0*:
www.outbackphoto.com/artof_b_w/bw_08/essay.html

[67] EFI: *Efi Designer Edition* is a RIP supporting TIFF, JPEG, PostScript and PDF:
www.efi.com

[68] *Speed-Mat Inc* offers several high quality mat-cutters, though expensive:
www.speed-mat.com/mat_cutter_standard.html

[69] *Itoya* offers art portfolios:
www.itoya.com/Catalogs/Profolio/Profolio_html/Art_profolio.htm

[70] *Prat* is one of the manufacturers of professional quality presentation materials. It's products are offered by many online stores:
www.prat.com

[71] **Giorgio Trucco is a well known photographer** and offers *Matworks!* as a free PC tool to calculate mat openings:
www.gt-photography.com/matworks.html

[73] **Aian Brios essay on** *QuickMats*, a program for virtual matting:
www.outbackphoto.com/portfoliowork/pw_25/essay.html

[74] **ShutterFreaks 'Photoshop Frames for** Printing' – a set of actions that create frames and mats in Photoshop:
www.shutterfreaks.com/Actions/ACsBigFrames.html

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[76] Premier Imaging Products. Offering fine art papers, as well as, Print Shield™, a fluid to protect-coated prints: www.premierimagingproducts.com

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[79] Bill Atkins: *Bill's Color Profile Downloads*. Here, Bill offers a number of very good ICC profiles for some Epson printers and several papers for free. There are also helpful comments on profiles: http://homepage.mac.com/billatkinson/FileSharing2.html

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[83] *inkAID*. A precoating to make uncoated papers suitable for inkjet printing: www.inkaid.com

[84] *Imatest*. This is an informative presentation on cameras, lenses, scanners and printers. Imatest is also an interesting program (test version available) to evaluate image quality of a picture or a print: www.imatest.com/docs/iqf.html
See also the photography page of Norman Koren including many technique descriptions: www.normankoren.com

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